Department of Public Works
Bureau of Engineering
Watershed, Ecosystem, and Restoration Services

ANNE ARUNDEL COUNTY
MARYLAND

Biological condition summary of targeted sites within the Galloway Creek watershed

July 2011

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I. Introduction. The Anne Arundel County Department of Recreation and Parks (R&P) administers the Jug Bay Wetlands Sanctuary. As reported on its website, Jug Bay is the largest park in the County's system and contains one of the largest tidal freshwater wetlands on the East Coast. Additionally, Jug Bay is part of the National Oceanographic and Atmospheric Administration's (NOAA) National Estuarine Research Reserve System. A memorandum of understanding between NOAA and the County calls for the County to evaluate and protect streams flowing to Jug Bay (C. Swarth, personal communication, August 2, 2011). In order to assist R&P in meeting its obligations to NOAA and to augment R&P's on-going research and monitoring activities within Jug Bay, the Watershed, Ecosystem, and Restoration Services (WERS) division within Anne Arundel County's Department of Public Works established targeted biological monitoring stations within the Galloway Creek watershed, one of the main stream systems delivering flow to the wetlands of Jug Bay. These stations were first sampled in 2007 and have been sampled annually since to develop a long-term data set that enables characterization of the general ecological health of Galloway Creek. The purpose of this brief report is to summarize our findings to date of the biological conditions within the Galloway Creek watershed.

II. Methods. Field data collection was conducted in accordance with the methods described in the Sampling and Analysis Plan (SAP) for Anne Arundel County Biological Monitoring and Assessment Program (Tetra Tech 2005), which are summarized below.

A. Field and Laboratory Methods

<u>*Watershed Description and Site Identification*</u>

The Galloway Creek watershed is located in the southwestern portion of the County (Figure 1). It has a total drainage area of approximately two square miles at its confluence with the Patuxent River and is drained by approximately nine miles of stream channel. The basin is dominated by forest, but also has significant levels of residential and agricultural land cover. Using spatial land cover data developed by the County, a summary of land cover observed in 2007 and 2004 is found in Table 1. Since 2004, land cover has changed very little. The major changes are found in the residential and woods categories, with three acres of residential presumably replacing three acres of woods during the four years between land use assessments.

Table 1. Summary of land cover in the Galloway Creek watershed.

Land Use	**2007**		**2004**	
	Acres	**% Area**	**Acres**	**% Area**
Commercial	9.0	0.8	8.9	0.8
Open Space	44.4	3.9	44.4	3.9
Pasture/Hay	12.1	1.1	12.1	1.1
Residential	191.4	16.9	188.4	16.7
Row Crops	142.9	12.6	142.9	12.6
Transportation	60.1	5.3	60.1	5.3
Water	1.8	0.2	1.8	0.2
Woods	669.5	59.2	672.6	59.5
Total	**1131.3**	**100.0**	**1131.3**	**100.0**

Source: Anne Arundel County WERS. Data are for the areas upstream of GC-01.

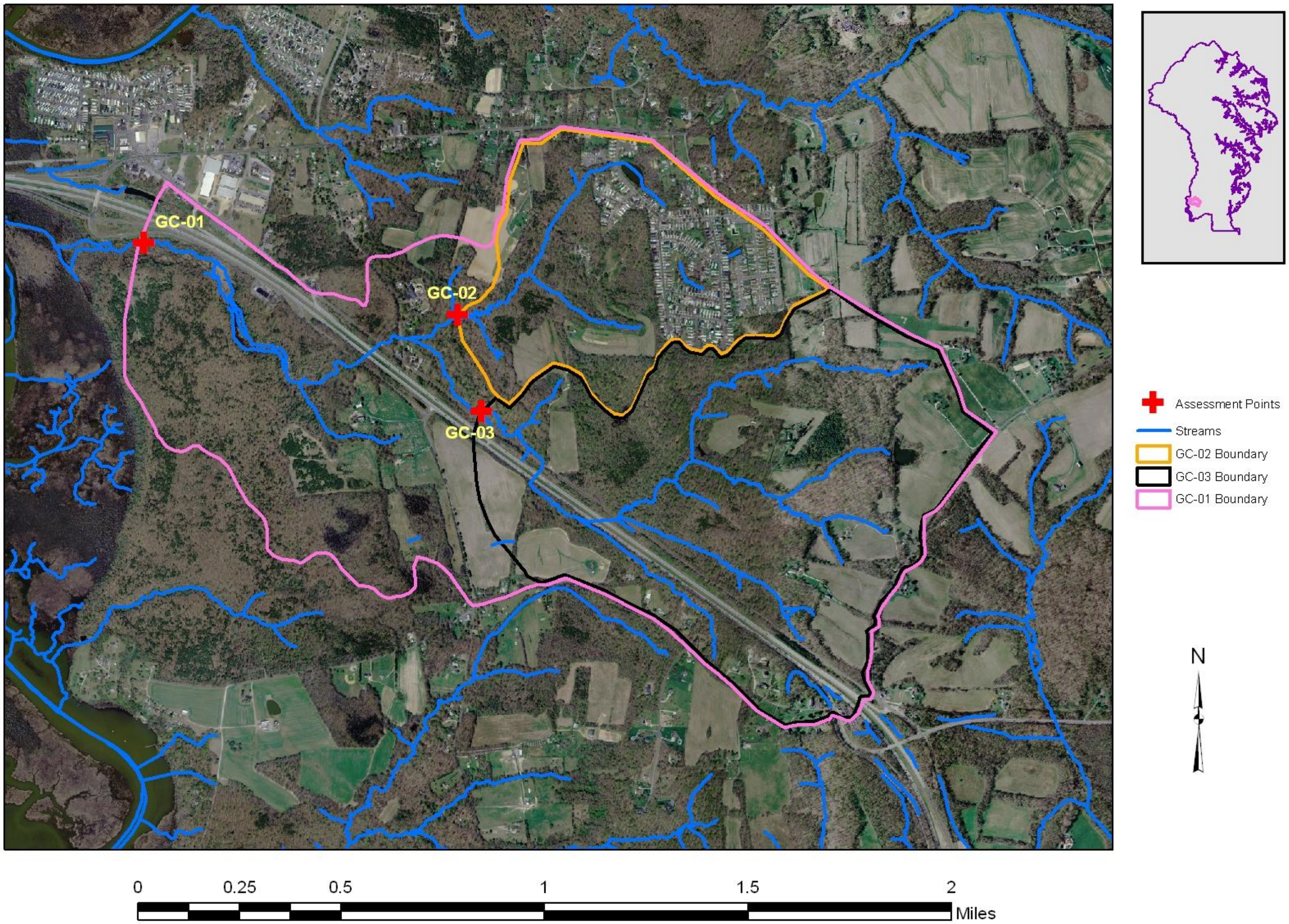


Figure 1. Location of County biological sample stations within the Galloway Creek watershed.

Targeted sites were established in Galloway Creek in 2007, as illustrated in Figure 1. Three sites were placed to balance ease of access with a desire to have an assessment point on the two major branches of the creek. Each site is briefly described below. All data discussed in this report, organized by sample station, are found in Appendix A.

Site GC-01 is located furthest downstream. For the 2010 sampling effort, a site sampled as part of the Countywide Biological Monitoring Program was substituted for the targeted site due to budgetary issues. For biological assessment purposes, the site should be comparable as the replacement site is approximately 450 feet upstream of GC-01. Geomorphic assessment work was not reported for this site as a different cross section from the original was established, making the results not comparable.

Sites GC-02 and GC-03 represent the two major branches of Galloway, which come together just north of MD Route 4. The drainage area to site GC-02 is 235 acres while the area to site GC-03 is 505 acres. Woods make up a large percentage of land area at both these sites. However, residential land use dominates GC-02 (~43% of total area) while agricultural and residential land are prevalent in GC-03 (19 and 11%, respectively).

Benthic Sampling and Processing

All sampling was conducted as required within the MBSS annual index period, which begins on March 1 and concludes at the end of April. At each site, benthic macroinvertebrates were collected from a 75-meter reach by sampling approximately 20 ft^2 of surface area with a D-frame net (595 µm mesh), with an emphasis on the most productive habitat types (e.g., riffles, snags, vegetated banks, sandy bottom) found within the reach. The most productive habitat types, in order of sampling preference include riffles, snags/logs that create a partial dam or are in a run area, undercut banks and associated root mats in moving water, gravel/broken peat and/or clay lumps in a run area, and detrital/sand areas in moving water. Kazyak (2001) also states that it is appropriate to move outside of the 75-meter reach, if necessary, to obtain the required 20 ft^2 of habitat surface area for sampling. Samples are primarily collected by jabbing the net into a habitat type (snags, root wads) to dislodge organisms or by disturbing the bottom substrate just upstream of the net allowing organisms to wash into the net. Larger surfaces such as logs or cobbles are often scrubbed by hand to further dislodge organisms. All sampled material (including leaf litter, small woody debris, and sediment) was composited in a 595 µm sieve bucket, placed in one or more one-liter sample containers and preserved in 70 - 80% ethanol. Internal and external labels were completed for each container. Samples were tracked on chain-of-custody forms and transported to the laboratory for sorting.

All taxonomic identifications were completed by an outside expert laboratory. Prior to identification, the sample was subsampled down to the target needed for a 100 insect assessment (80 to 120 insects, total). Subsamplng of the original sample involved spreading the entire sample on a Caton gridded tray (Caton 1991, Flotemersch et al. 2006) with 30 square grids (6-cm each), which allows isolation of physically defined amounts of sample material (leaf litter detritus, sticks, substrate particles) from the total sample and the separation/removal of the organisms from that material. A minimum of four grids were selected at random and sorted to completion until the target number of organisms (100 ± 20%) was reached. If more than 40 organisms are found in the first grid, the original four grids are re-spread on a separate Caton tray and another four grids are then randomly selected for sorting, and consecutive grids are selected until the target number is reached.

Benthic Taxonomy

Primary taxonomy on each sample (Boward and Friedman 2000) was performed by the contract laboratory and individual organisms were identified primarily to genus level. In some cases, (e.g., when individuals were early instars or had damaged or missing diagnostic morphological features), identification was left at genus-group, subfamily, or family level. Taxonomic data were received in Excel spreadsheets. Functional feeding group, habit, and tolerance value designations were assigned to each taxon according to Merritt and Cummins (1996), Barbour et al. (1999), and Stribling et al. (1998). The tolerance value assigned to each taxon is based on its ability to survive and reproduce in the presence of chemical pollution, hydrologic alteration, or habitat degradation (Stribling et al. 1998; Bressler et al. 2005, 2006; Flotemersch et al. 2006).

Stream Physical Habitat Assessments Methods

Physical habitat quality was visually assessed at each site using the USEPA Rapid Bioassessment Protocol (RBP; Barbour and Stribling 1994; Barbour et al. 1999) The RBP evaluates 10 parameters that describe instream physical characteristics, channel morphology, and riparian vegetation and stream bank structure. Each parameter was scored as either optimal, suboptimal, marginal, or poor and given a corresponding score based on a 20-point scale (20 = best, 0 = worst), or 10-point scale for individual bank parameters. The following 10 parameters were evaluated:

- pool substrate characterization
- epifaunal substrate/available cover
- pool variability
- sediment deposition
- channel flow status
- channel alteration
- channel sinuosity
- bank stability
- vegetative protection
- riparian vegetative zone width

Water Quality

Conductivity, dissolved oxygen, pH, and temperature were measured at each site using a multiple parameter water quality meter, which was calibrated according to the specifications provided by the manufacturer. All calibrations were recorded on a calibration log sheet.

Geomorphic Assessment

Annual surveys were conducted in the sampling reach in which a monumented, representative cross section was established in 2007, the first assessment year. During each year, a simplified longitudinal profile, a cross section survey, and a pebble count were performed. Data from these measurements were recorded on field forms and used to determine the stream type of each reach as categorized by the Rosgen Stream Classification (Rosgen 1996). Using basic geomorphic parameters described in greater detail below, stream reaches were classified into one of 42 basic stream types. Details on each of the types can be found in Rosgen (1996) and are briefly described in the Data Analysis section of this report.

The simplified longitudinal profile is used to identify indicators and elevations of the bankfull discharge (bankfull indicators) and to determine the water surface slope throughout the reach. Once the bankfull indicators were identified, elevation data on the channel thalweg, water surface, and bankfull indicator were collected, at a minimum, at the upstream and downstream ends of the representative reach on the same bed feature.

At each station, the cross section was installed in riffle or crossover section as close to the midpoint of the 75-meter reach as possible. If no riffles existed within the reach, cross sections were installed in a nearby run or glide within a straight transitional reach (i.e., not in the pool of a meander). Cross section monuments, consisting of iron reinforcement bars hammered to within six inches of the ground surface and topped with yellow caps, were installed at each station.

Each cross section survey consisted of measuring the topographic variability of the associated stream bed, floodplains, and terraces, including:

- changes in topography,
- top of each channel bank,
- elevations of bankfull indicators,
- edge of water during time of survey,
- thalweg or deepest elevation along active channel, and
- depositional and erosional features within the channel.

During the cross section survey, the following measurements and calculations of the bankfull channel that are critical for determining the stream type of each reach also were collected.

- Bankfull Width (Wbkf): the width of the channel at the elevation of bankfull discharge or at the stage that defines the bankfull channel.
- Mean Depth (Dbkf): the mean depth of the bankfull channel.
- Bankfull Cross Sectional Area (Abkf): the area of the bankfull channel, estimated as the product of bankfull width and mean depth.
- Width Depth Ratio (Wbkf/Dbkf): the ratio of the bankfull width divided by the mean depth.
- Maximum Depth (Dmbkf): the maximum depth of the bankfull channel, or the difference between the thalweg elevation and the bankfull discharge elevation.
- Width of Floodprone Area (Wfpa): the width of the channel at a stage of twice the maximum depth. If the width of the floodprone area was far outside of the channel, its value was visually estimated or paced off.
- Entrenchment Ratio (ER): the ratio of the width of the floodprone area divided by bankfull width.
- Sinuosity (K): ratio of the stream length divided by the valley length or the valley slope divided by the channel slope. Sinuosity was visually estimated or the valley length was paced off so that an estimate could be calculated. In some cases, this parameter was estimated using GIS digital maps.

To determine the size of channel substrate within the 75-meter reach segments, a Wolman Pebble Count (Wolman 1954) was performed, which consists of stratifying the reach based on its frequency of pools, riffles, runs, and glides. The goal of the pebble count is to measure the intermediate axis of 100 particles across ten transects, or ten particles in each of ten transects across the bankfull width and calculate the median particle size, the D50, of the reach. This value was then used for categorizing the sites into the Rosgen Stream Classification (Rosgen 1996). The number of transects performed in each bed feature was determined by measuring or visually estimating the percentage of reach length for each type of bed feature. For example, if riffles covered 20 percent of the reach length, then 20 percent of the pebble count, or two transects, were performed in riffles. If a channel was clearly a sand or silt bed channel with no distinct variation in material size, the pebble count was not performed, and the D50 was visually estimated. However, if the channel did have changes in bed material size from feature to feature, a full pebble count was performed.

B. Data Analysis

Physical Habitat

The 10 RBP metric scores are summed to obtain a final habitat score, which is then compared to a reference condition score. However, since there was no RBP data for reference sites within Anne Arundel, a reference condition based on similar studies from Prince George's County, Maryland (Stribling et al. 1999) was used. The values were compared to the maximum possible score (168) for overall percent comparability for each site.

Table 2 provides narrative ratings that correspond to physical habitat quality scores. These scores express the potential of a stream or watershed to support a healthy biological community. Percentages and their narrative ratings were adapted from Plafkin et al. (1989).

Table 2. EPA RBP Scoring

Score	Narrative
151 +	Comparable
126 – 150	Supporting
101 – 125	Partially Supporting
0 – 100	Non-supporting

Source: Stribling et al. 1999

Benthic Index of Biotic Integrity (BIBI)

The biological condition indicator used for this assessment is the Index of Biological Integrity (IBI; Karr et al. 1986), which uses characteristics of the benthic macroinvertebrate assemblage structure and function to assess the overall water resource condition. The Benthic IBI (BIBI) was developed by the Maryland Biological Stream Survey (MBSS) and calibrated for different geographic areas of Maryland (Stribling et al. 1998). In 2005, MBSS revised the BIBI (Southerland et al. 2005). The revised benthic metrics calculated in this report were those selected and calibrated specifically for Maryland Coastal Plain streams. The seven metrics calculated for each of the benthic macroinvertebrate samples were:

- **Total Number of Taxa.** The taxa richness of a community is commonly used as a qualitative measure of stream water and habitat quality. Stream degradation generally causes a decrease in the total number of taxa.

- **Number of EPT Taxa.** Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) are generally sensitive to degraded stream conditions. A low number of taxa representing these orders is indicative of stream degradation.
- **Number of Ephemeroptera.** Mayflies are generally sensitive to pollution and the number of mayfly genera represented by individuals in a sample can be an indicator of stream conditions, generally decreasing with increasing stress.
- **Percent Intolerant to Urban.** This is the percentage of the benthic sample that is intolerant to urban stressors. This metric decreases with increased stream degradation.
- **Percent Ephemeroptera**. The degree to which mayflies dominate the community can indicate the relative success of these generally pollution intolerant individuals in sustaining reproduction. The presence of stresses will reduce the abundance of mayflies relative to other, more tolerant individuals; although, some mayfly groups, such as several genera of the family Baetidae, are known to increase in numbers in cases of nutrient enrichment.
- **Number of Scrapers.** Specialized feeders such as scrapers tend to be more sensitive species and are thought to be well represented in healthy streams, and tend to decrease with increasing stressors.
- **Percent Climbers.** This

Table 3. MBSS BIBI Metrics

Metric	Threshold 1	Threshold 3	Threshold 5
Number of Taxa	< 14	14-21	>= 22
Number of EPT Taxa	< 2	2-4	>= 5
Number of Ephemeroptera Taxa	< 1	1	>= 2
Percent Intolerant to Urban	<10	10-27	>= 28
Percent Ephemeroptera	< 0.8	0.8-10.9	>= 11
Number of Scraper Taxa	< 1	1	>= 2
Percent Climbers	< 0.9	0.9-7.9	>= 8

Source: Southerland et al. (2005)

Table4. MBSS BIBI Scoring

BIBI Score	Narrative Ranking	Characteristics
4.0 – 5.0	Good	Comparable to reference streams considered to be minimally impacted, biological metrics fall within the upper 50 % of reference site conditions.
3.0 – 3.9	Fair	Comparable to reference conditions, but some aspects of biological integrity may not resemble the qualities of minimally impacted streams.
2.0 – 2.9	Poor	Significant deviation from reference conditions, indicating some degradation. On average, biological metrics fall below the 10^{th} percentile of reference site values.
1.0 - 1.9	Very Poor	Strong deviation from reference conditions, with most aspects of biological integrity not resembling the qualities of minimally impacted streams, indicating severe degradation. On average, most or all metrics fall below the 10^{th} percentile of reference site values.

is the percentage of the benthic sample living primarily on stem type surfaces. Climbers tend to decrease with increasing stressors.

Each metric was scored on a 5, 3, 1 basis (5 being the best, 1 being the worst) according to stream health. Metric scoring criteria are listed in Table 3 above. Overall biological index scores are obtained by summing of the seven metric scores for each site, and dividing by the number of metrics (7). Using the format established by MBSS, the resulting value is then compared to the index scoring criteria for translation into narrative categories (Table 4).

Table 5. Maryland COMAR Standards

Parameter	Standard
pH	6.5 to 8.5
Dissolved Oxygen (mg/L)	Minimum of 5 mg/L
Conductivity (mS/cm)	No state standard
Turbidity (NTU)	Maximum of 150 NTU and maximum monthly average of 50 NTU
Temperature (°C)	Maximum of 32°C (90°F) or ambient temperature, whichever is greater

Source: COMAR 26.08.02.03-3

Water Quality

Water quality data were compared to Maryland water quality standards for Use I streams. Use I streams have designated uses for water contact recreation and protection of nontidal warm water aquatic life. Table 5 lists the water quality standards for these streams.

Geomorphic Assessment

Geomorphic field data were compared to regional relationships of bankfull channel geometry developed by the U.S. Fish and Wildlife Service for streams in the Maryland Coastal Plain (McCandless 2003). This comparison is a crucial step in verifying whether field determined bankfull estimates are appropriate or within a range of known values for drainage basins of similar size. Determination of bankfull indicators can be difficult in potentially impacted streams like those assessed for this report. To be cautious, field staff would typically identify two or more possible topographic features within the cross section as possible bankfull indicators. Occasionally, changes to the field-called bankfull indicator were made in the office if, based upon an inspection of the plotted cross section and photographs, another identified indicator or obvious slope break or other observable feature gave better agreement with the regional relationships that have been well established in this physiographic region. However, no changes to the field-derived call were made if there was no obvious other potential indicator observable in the cross section and only one bankfull indicator was called in the field or if there was reasonable (±15% of the expected value for the drainage area upstream of the sample point) agreement between the original call and the Coastal Plain regional relationships.

After field data were compared to the regional relationships and determined to be accurate estimates of the bankfull channel parameters, the longitudinal profile survey, the cross section survey, and the pebble count data were analyzed for each assessment site. These data were then used to identify each stream reach as one of the stream types categorized by the Rosgen Stream Classification (Rosgen 1996). In this classification methodology, streams are categorized based on their measured field values of entrenchment ratio, width/depth ratio, sinuosity, water surface slope, and channel materials according to the table in Appendix B: Rosgen Stream Classification. As described in Rosgen (1996), the classification system categorizes streams into broad stream types, which are identified by the letters, A, G, F, B, E, C, D, and DA. Additionally, when a numeric code for dominant bed material is added, a total of 41 unique types exist in this scheme.

The most entrenched streams are the A, G, and F channels. In these streams, flood flows are confined to their channels with little relief provided by a floodplain. Type A streams generally occur in narrow high relief valleys and are generally narrow, deep, confined, and entrenched streams with cascading step-pools and low sinuosity. These streams can be very stable if the bed material consists mainly of bedrock or boulders. Type G streams occur in moderate gradient valleys and also are generally narrow and deep. These streams also have step-pool systems, but are generally more sinuous and gully-like than A streams. G streams are considered unstable and commonly have grade control problems and high bank erosion rates. Type F streams occur in more gentle gradients and have higher width/depth ratios than A and G streams. F streams are generally entrenched in highly weathered materials that make these streams laterally unstable. These streams usually have riffle-pool morphologies, greater sinuosity than A and G streams, and high bank erosion rates (Rosgen 1994, Rosgen 1996).

Type B streams are moderately entrenched. These streams have better floodplain connectivity than the entrenched A, G, and F streams. B streams are found in narrow valleys of moderate relief and generally have very stable planforms, profiles, and banks. Riffles and rapids dominate these channels with intermittent pools (Rosgen 1994, Rosgen 1996).

The least entrenched single thread channels are the type E and C streams. Type E streams are commonly narrow and deep but have very wide and well-developed floodplains. These streams are highly sinuous with well-vegetated banks, a riffle-pool morphology, and low gradients; occurring in broad valleys and meadows. E streams are generally very stable, efficiently conveying flood flows and transporting sediment. Type C streams have wider and shallower channels with well-developed floodplains and very broad valleys. These streams have riffle-pool morphology, point bar depositional features, and well-defined meandering channels (Rosgen 1994, Rosgen 1996).

Type D and DA streams are multi-thread streams (Rosgen 1994, Rosgen 1996). These stream types are uncommon in the mid-Atlantic and somewhat rare in Anne Arundel County. None were observed during this assessment and so are not discussed further.

To facilitate the data analysis and classification work, an Excel spreadsheet developed by the Ohio Department of Fish and Game’s Division of Soil and Water Conservation specifically designed for Rosgen stream classification was used to analyze the channel data collected and help classify the stream reaches.

Because the goal of the geomorphic assessment component of this study is to support the biological assessments, a full set of geomorphic parameters was not collected. Therefore, the data have certain limitations that should be noted:

- Pebble count data were collected for stream classification purposes only and are not appropriate for use in hydraulic calculations of bankfull velocity and discharge. This is particularly the case for the many sand bed channels in the study area, where data on the dune height would be used instead of the 84th percentile particle size, or D84, in hydraulic calculations. Dune height data were not collected for this study.

- No detailed analyses of stream stability were performed for this study. Statements referring to stream stability are based on observations and assumptions, which were founded on fundamental geomorphic principles. Conclusive evidence of the stability of the sampling units assessed could only be obtained after detailed watershed and stream stability assessments were performed.

Finally, in addition to classifying the assessment reach each year, a year-to-year comparison of the stream cross section is made to determine if significant changes in the channel are taking place. A summary of the stream channel physical data collected in this study is included in Appendix B: Geomorphic Assessment Results.

III. Result. Conditions within Galloway Creek are summarized in Table 6 and Figure 2. Detailed summaries of the data discussed below are found in Appendix A.

Table 6. Summary of Average BIBI and RPB scores from 2007 to 2010.

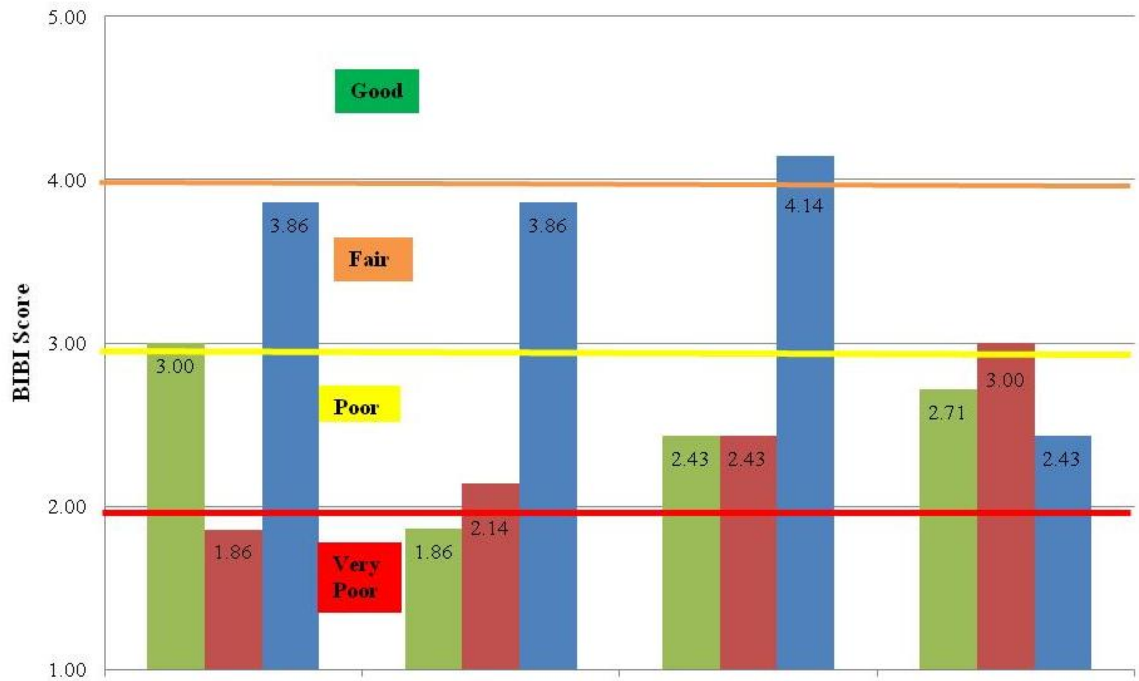
Station	BIBI Score (±SD) Narrative Condition	RBP Score (±SD) Narrative Condition
GC-01	2.43 (±0.49) Poor	117 (±6.6) Partially Supporting
GC-02	2.36 (±0.49) Poor	127 (±12.4) Supporting
GC-03	3.57 (±0.77) Fair	115 (±18.8) Partially Supporting

At site GC-01, BIBI scores ranged from a high of 3.00 (Fair) to a low of 1.86 (Very Poor), with an average score for the four years sampled of 2.43, placing this site in the Poor category. RBP habitat scores averaged 117 (Partially Supporting) and were consistently measured in this category.

For GC-02, the average BIBI score was 2.36, with an identical range of scores as found at GC-01 (3.00 to 1.86). The average BIBI score was lowest at this station. Conversely, average habitat conditions assessed by RBP rated this station as having the highest quality habitat of the three sites, with Supporting quality three of four years and averaging Supporting over the assessed years.

Site GC-03 had the highest average BIBI score observed during this assessment with an average score of 3.57, placing this station solidly in the Fair category. Scores ranged from 4.14 (Good) to 2.43 (Poor) observed in 2010, the first time a score lower than Fair was measured at this station. RBP habitat condition averaged as Partially Supporting (115). Scores ranged from Supporting (139) to Non-supporting (95), but only one year of four was evaluated as Non-supporting.

A)



B)

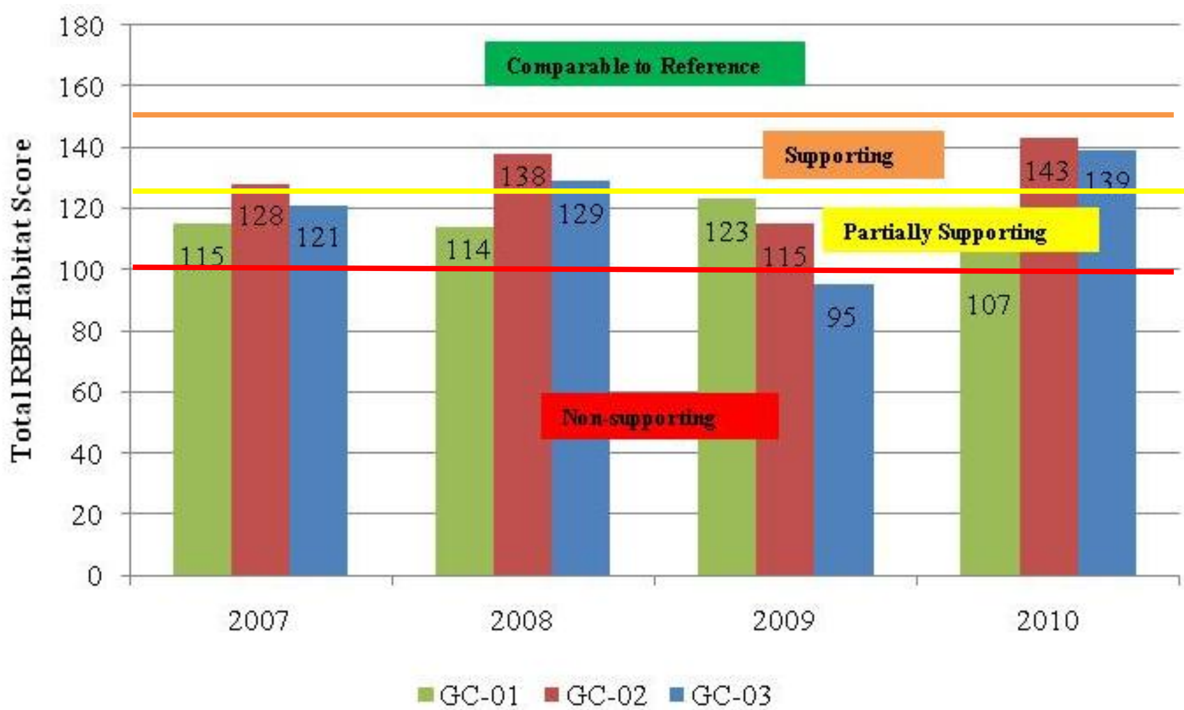


Figure 2. Summary of A) Biological and B) Habitat conditions observed at the Galloway Creek targeted sites.

Geomorphic conditions at the three stations were fairly consistent across the sample period. As illustrated in Figure 3, the G type was observed consistently at site GC-02, the B type was found in all years at GC-03, and the E stream type was observed at GC-01. At GC-01, no classification work was performed in 2010 due to the change in site location.

Water chemistry conditions are summarized in Table 7. The sites showed no serious impairments in dissolved oxygen, pH, temperature, or conductivity. Dissolved oxygen values were above 5 mg/L during all measurements. No temperature values exceeded the acceptable maximum value of 32° C. While there is no state standard for this parameter, conductivity values were also in an acceptable range for streams in the Coastal Plain based upon the best professional judgment of the authors.

Table 7. Summary of average values for water quality observations made during biological assessments, 2007-2010.

Station	**Conductivity (µS/cm)**	**Dissolved Oxygen (mg/L)**	**pH (units)**	**Temperature (deg, C)**
GC-01	277	9.31	7.00	9.75
GC-02	222	9.10	7.37	11.77
GC-03	242	9.60	7.04	10.32

IV. Conclusions and Recommendations

<u>Biology and Habitat</u>

Generally, habitat and biological community conditions tend to be related. The quality of reach habitat conditions dictates the level of potential biological health that a particular site can achieve, all other factors being equal. In essence, this means that sites with "Good" BIBI scores tend to be associated with "Comparable" habitat, those with "Fair" BIBIs scores tend to have "Supporting" habitat, and so on. When biological community health and habitat conditions do not correlate well, it is a possible indicator of human impacts, which tend to manifest themselves in two basic ways.

First, when biological conditions are better than expected for the habitat quality observed (e.g., a BIBI of "Good" and a habitat rating of "Partially Supporting" or "Non-supporting"), nutrient enrichment from agricultural activities and other sources is often suspected. Such enrichment can cause subtle, adverse changes in the ecological conditions of a stream system. For example, additional nutrients can alter stream foodwebs such that some invertebrate groups are favored over others, resulting in a loss of biodiversity (Dang et al. 2009, Evans-White et al. 2009). While such condition changes can alter some metrics favorably (e.g., increasing total taxa observed), these changes can be indicative of a stream system out of balance. Conversely, when biological conditions are worse than expected for the habitat quality observed (e.g., a BIBI of "Very Poor" and a habitat rating of "Comparable" or "Supporting"), then water chemistry impairments associated with watershed development are typically thought to foster this imbalance.

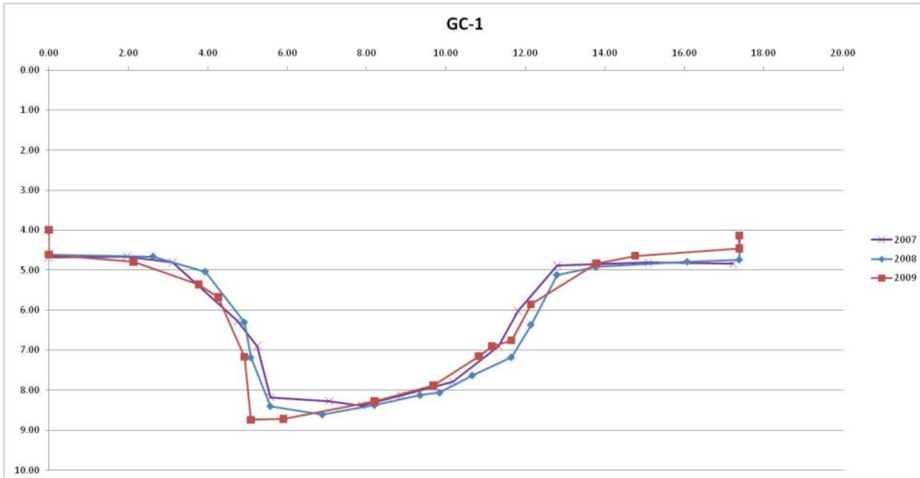
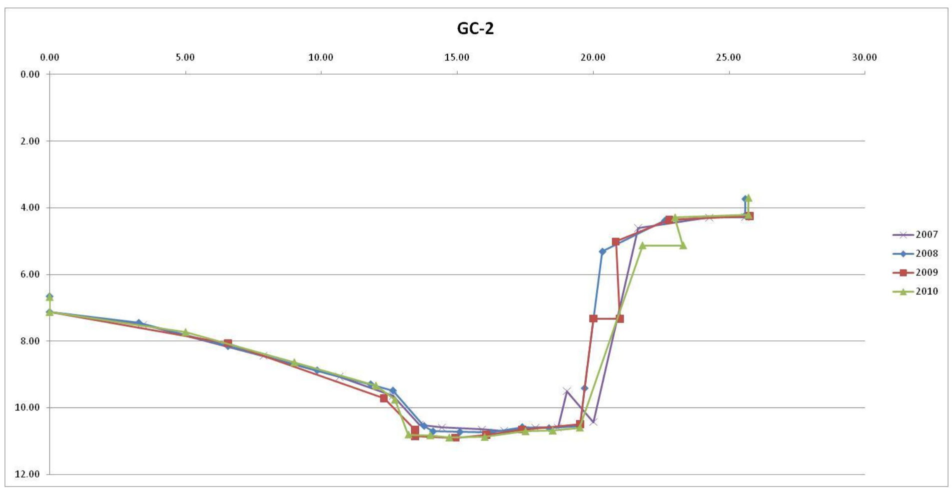
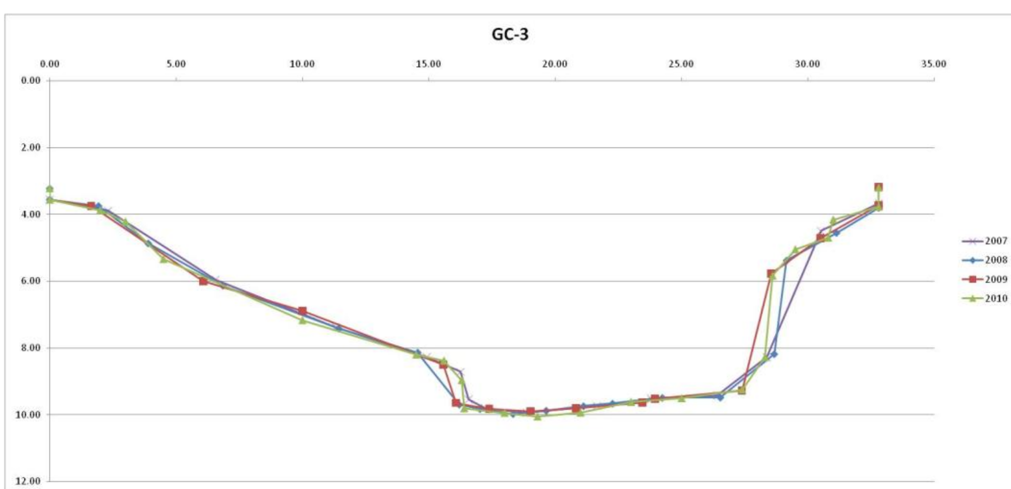
<u>GC-01</u> *2007: E5* *2008: E5* *2009: E5* *2010: --*	
<u>GC-02</u> *2007: G5c* *2008: G5c* *2009: G5c* *2010: G5c*	
<u>GC-03</u> *2007: B5c* *2008: B5c* *2009: B4c* *2010: B4c*	

Figure 3. Comparisons of cross section measurements at the three monitoring stations along with their associated stream types. No 2010 data available for GC-01. The zero point for all measurements is located on the left bank facing downstream.

As illustrated in Table 6, for GC-01 the average of habitat and BIBI scores over the course of the study shows that biological conditions and habitat quality are in sync with each other (Poor BIBI and Partially Supporting habitat conditions). GC-01, the downstream station, had moderate levels of imperviousness (8%) and includes residential, commercial, and agricultural lands (see Appendix A for land use data for each site). While 50-60 different taxonomic groups were observed at this station during the assessment period, the dominant groups were isopods (*Caecidotea* sp.) and chironomid midges (variety of taxa) with occasional meaningful contributions (>15% of a given year's sample) from various worms (*Stylaria*, *Chaetogaster* sp.) and riffle beetles (*Stenelmis* sp.) (See Appendix B for a summary of all macroinvertebrates observed during this assessment). These groups have been shown to be moderately tolerant to water quality conditions associated with developed lands.

For GC-02, biological conditions are impaired with respect to observed habitat conditions, having an average habitat condition of Supporting and an average biological condition judged Poor. However, the overall BIBI has improved over the course of the study, moving from Very Poor in 2007 to Fair in 2010. The reason for this improvement is unclear. The contributing drainage area to GC-02 had the highest level of impervious surface observed (~17%), comprised of mostly older residential and commercial lands developed before modern stormwater management regulations were in place, including a large manufactured home development with an on-site wastewater treatment plant. Many studies have shown that levels of impervious surface above 10% are also associated with degraded biological communities (Cuffney et al. 2010, Paul and Meyer 2001). Various chironomid midge groups dominated the samples between 2007 and 2010, comprising over 50% of all invertebrates collected. Additionally, worms (*Nais* sp.) and riffle beetles (*Stenelmis* sp.) were occasional large fractions of given samples. Water quality issues associated with uncontrolled or minimally controlled stormwater are likely responsible for any impacts. It is unknown if any best management practices have been retrofitted into the developed areas of this basin, but such retrofits may explain improving conditions within the reach. Finally, given the relatively high presence of particular oligochaete worms (Family Naididae) in these samples (~4% to over 20% of organisms per year collected; ~10% of all organisms collected), it is possible that sewage treatment plant discharges or failing septic system inputs are impacting this reach, although no direct evidence of such contamination was observed by field crews.

At GC-03, biological conditions are somewhat better than expected for observed habitat conditions, having an average biological condition of Fair and Partially Supporting habitat. As shown in Appendix B, this site had high percentages of stoneflies (*Amphinemura* sp., *Haploperla* sp.) across all years, with these two groups making up nearly 40% of the total insects observed. Also, mayflies (*Acerpenna* sp.) were found in meaningful numbers in 2009 (~21%) and comprised ~6% of all insects collected at this site. These sensitive groups were absent or minimally represented at the other stations. Additionally, moderately tolerant amphipods (*Gammarus* sp.) made up approximately 9% of the total insects collected. As reported in Appendix A, GC-03 has the least developed land upstream and includes the highest percentage of agriculture (~20%), which may be causing the observed imbalance due to possible nutrient enrichment of receiving waters from these land uses. It should be noted, however, that no water quality data were collected as part of this study beyond those summarized in Table 7, so enrichment conditions cannot be confirmed. While the BIBI took a sharp downturn in 2010, from Fair to Poor, it should be noted that the discovery of a single Ephemeroptera taxon at this site would have improved the index score to a value of 3.00, or Fair, illustrating one limitation of multimetric approaches in the evaluation of watershed health. Overall, GC-03 biological conditions indicate moderately high ecological health.

Physical Channel Conditions

The E5 channel has been consistently observed at site GC-01. This site has a broad, flat, wetland-dominated floodplain area. Banks are low and moderately well vegetated and flood flows easily access the floodplain. Woody debris is present in moderate amounts. Beaver activity has been frequently observed by the field crews over the years. E type channels are considered stable types, maintaining pattern, cross sectional dimensions, and stream slope as long as hydrologic and land use characteristics remain stable. The E type is a possible endpoint of the evolutionary sequence illustrated in Figure 4 (Simon and Hupp 1986). Some enlargement of the bankfull channel area, however, has been observed between 2007 and 2009, increasing from around 12 ft^2 to about 16 ft^2, a boost of approximately 30%. It is possible that some of this change is due to measurement error along the cross section. Slope, median streambed particle size, and sinuosity did not change in a meaningful way from year to year.

At GC-02, the G stream type was observed during all assessments. Typical of the G type, the reach at this location has dropped below the original floodplain elevation and begun the process of reestablishing itself at a lower elevation (Figure 4). Bank instability on the right bank was observed by field crews, including a small undercut not well mapped in the cross section plots in Figure 3. Additionally, the bankfull channel cross section appears to have contracted compared to the 2007 baseline value, moving from 8.8 ft^2 to 6.9 ft^2, a decrease of approximately 20%. What cannot be ruled out, however, is that the presumed change in cross sectional area may be the result of measurement error associated in the profiling of the undercut right bank. It should be noted that the bed on the left side of the channel shows clear evidence of downcutting over time. Evaluating the possible bank and bed stability conditions together, this reach is likely in a moderate phase of channel evolution, possibly in late Stage III, consistent with a Rosgen G type channel, an unstable type that eventually adjusts itself to a quasi-equilibrium state (Rosgen 1996). The relatively high levels of imperviousness are the likely drivers of this adjustment as the channel resizes itself to manage increased flows associated with urbanization (Paul and Meyer 2001). Little change from year to year was observed in slope, median stream bed particle size, or sinuosity.

Site GC-03 was classified as a B type throughout the assessment period. The site has well vegetated, gently sloping banks and moderate entrenchment. The B type is typically stable and could be a possible endpoint of the channel model illustrated in Figure 4. During the assessment period, very little change occurred in overall bed elevation (Figure 3). However, there appears to have been some bank erosion on both banks, but it is possible that measurement error over the cross section may account for some of these differences. In 2009, the median particle size moved from sand (<2 mm) to lower end of the gravel class (2 to 64 mm). There were no meaningful changes in slope or sinuosity during the assessment. Given the observed bed and bank characteristics, this reach also appears to be in a late stage of channel evolution (Stage 4 or 5). The stable bed conditions and larger bed materials likely also contribute to the higher BIBI scores observed in this reach as sensitive insect groups that drive the index tend to prefer coarser substrates (Cobb et al. 1992, Holomuzki 1996).

In summary, the stream types observed at each station have changed little since 2007, but as illustrated in Figure 3, channel cross sections have possibly adjusted during this time. Two of three stations (GC-01, GC-03) are characterized by Rosgen types considered stable endpoints and are visually similar in appearance to stable configurations detailed in the Channel Evolution Model (CEM) developed by Simon and Hupp (1986). GC-02 appears to be experiencing more on-going instability, is classified as an unstable Rosgen type, and appears to be undergoing degradation as described by the CEM, particularly compared to the other two reaches.

From: Simon and Hupp (1986)

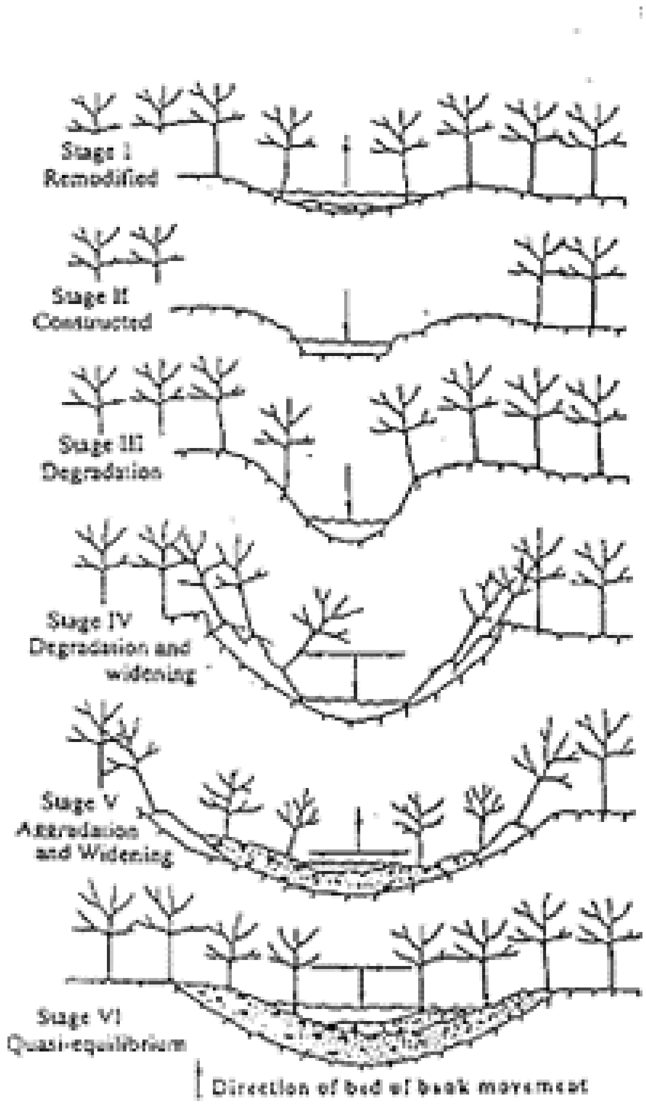


Figure 4. Channel evolution model.

Based upon the information presented in this report, the following recommendations are made:

Investigate basin water quality conditions. A synoptic water quality survey should be performed in the Galloway Creek watershed. Nutrients (nitrogen and phosphorus) and a suite of metals should be evaluated. At GC-02, due to presence of an abundance of oligochaete worms in the samples, enrichment associated with sewage discharges or failing septic systems should be investigated upstream of this site. For GC-03, possible impacts of agricultural land uses in the basin might warrant sampling for common agricultural chemicals like atrazine, especially in light of the sudden depression in BIBI scores.

Continue stability measurements. To better understand the stability trajectory of these reaches, geomorphic measurements should be continued at these sites. Improvements should be made in measurement techniques to ensure that undercut areas of particular banks are better tracked.

Determine extent, feasibility of stormwater Best Management Practice (BMP) implementation. A thorough investigation of any past BMP retrofits should be conducted. The upward trend at GC-02 might be explained if a series of on-going retrofits has occurred in the contributing drainage area, a task beyond the scope of this current project. If no such retrofits have been implemented, opportunities for BMP retrofits should be sought in order to continue the apparent improvements in the biological community at this site.

Continue bioassessment work. To understand long-term trends at the sites, these sites should continue to be sampled for a total of 10 years, which would provide thorough characterization of biological conditions in the Galloway Creek watershed.

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Appendix A:
Individual Site Data Summaries

DATA SUMMARY: GC-1

Upstream 2007

Upstream 2008

Upstream 2009

Downstream 2010— Substitute site R2-21-10

Site Coordinates: 38.80844°,76.70312° (R2-21-10 coordinates)

Location Description: For 2010, a random site established approximately 450 feet upstream of GC-01 for the Countywide Biological Monitoring Program was substituted for GC-01 due to budgetary constraints.

Land Use	2007		2004	
	Acres	% Area	Acres	% Area
Commercial	9.0	0.8	8.9	0.8
Open Space	44.4	3.9	44.4	3.9
Pasture/Hay	12.1	1.1	12.1	1.1
Residential	191.4	16.9	188.4	16.7
Row Crops	142.9	12.6	142.9	12.6
Transportation	60.1	5.3	60.1	5.3
Water	1.8	0.2	1.8	0.2
Woods	669.5	59.2	672.6	59.5
Total	**1131.3**	**100.0**	**1131.3**	**100.0**

Impervious Summary (2007)

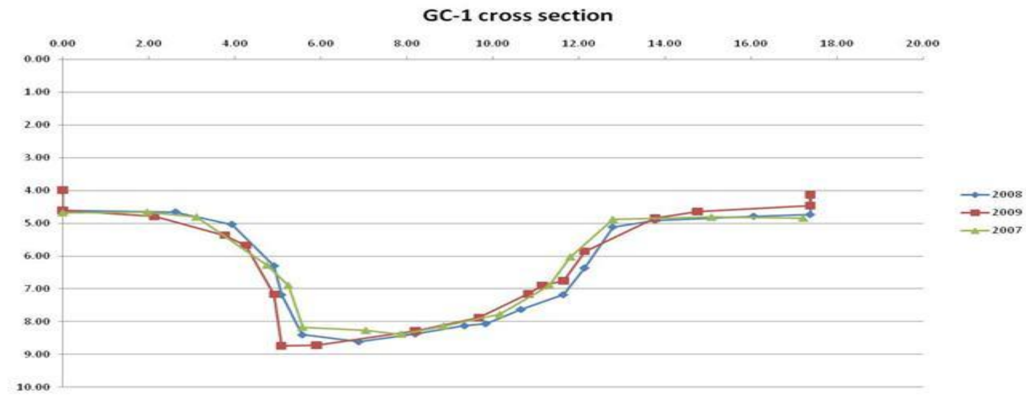
Impervious Surface (acres)	Total Area Above Site	% Impervious
90.1	1131.8	8.0

Habitat Conditions	**2010***	**2009**	**2008**	**2007**
EPA Narrative Rating	**Partially Supporting**	**Partially Supporting**	**Partially Supporting**	**Partially Supporting**
Habitat Score	**107**	**123**	**114**	**115**
Bank Stability- Left Bank	3	6	6	4
Bank Stability- Right Bank	4	8	5	7
Channel Alteration	20	7	15	9
Channel Flow Status	16	18	16	20
Channel Sinuosity	8	9	7	9
Epifaunal Substrate/ Available Cover	9	14	12	13
Pool Substrate Characterization	3	11	8	8
Pool Variability	7	10	11	11
Riparian Vegetative Zone Width- Left Bank	10	10	10	10
Riparian Vegetative Zone Width- Right Bank	6	5	1	5
Sediment Deposition	13	11	10	9
Veg. Protection (Left Bank)	4	6	7	6
Veg. Protection (Right Bank)	4	8	6	4

*Assessment performed at site located just upstream of GC-01

Biological Conditions	**2010***	**2009**	**2008**	**2007**
Narrative Rating	**Poor**	**Poor**	**Very Poor**	**Fair**
BIBI Score	**2.71**	**2.43**	**1.86**	**3.00**
Metric Scores				
Total Taxa Score	1	5	3	5
EPT Taxa Score	1	3	1	1
Ephemeroptera Taxa Score	3	1	1	3
Intolerant Urban % Score	5	1	3	3
Ephemeroptera % Score	3	1	1	3
Scraper Taxa Score	5	1	1	1
% Climbers	1	5	3	5
Measured Metric Values				
Total Taxa	13	27	20	30
EPT Taxa	1	2	1	1
Ephemeroptera Taxa	1	0	0	1
Intolerant Urban %	40.4	2.54	18.87	19.82
Ephemeroptera %	0.9	0.00	0.00	2.70
Scraper Taxa	4	0	0	0
% Climbers	0	27.97	5.66	9.01

*Assessment performed at site located just upstream of GC-01



Geomorphic Conditions

Parameters	2007	2008	2009	2010
Bankfull Width (ft)	7.3	7.2	8.0	
Mean Bankfull Depth (ft)	1.7	1.7	2.0	
Floodprone Width (ft)	>200	272	360	
Entrenchment Ratio (ft./ft)	27.3	37.7	45.2	
Width to Depth Ratio (ft/ft)	4.3	4.3	3.9	
Cross Sectional Area (ft^2)	12.4	12.0	16.1	
Slope (%)	1.1	0.67	0.83	
Sinuosity (ft/ft)	1.2	1.3	1.1	
D50 (mm)	0.28	0.21	0.45	
Adjustments?	↑Sin	↑Sin	↑Sin	
Rosgen Stream Type	**E5**	**E5**	**E5**	**No Data**

DATA SUMMARY: GC-2


Upstream 2007


Upstream 2008


Downstream 2009


Upstream 2010

Site Coordinates: 38.80590° , 76.68731°

Location Description:
Approximately 450 feet south of Miracle Temple Church parking lot.

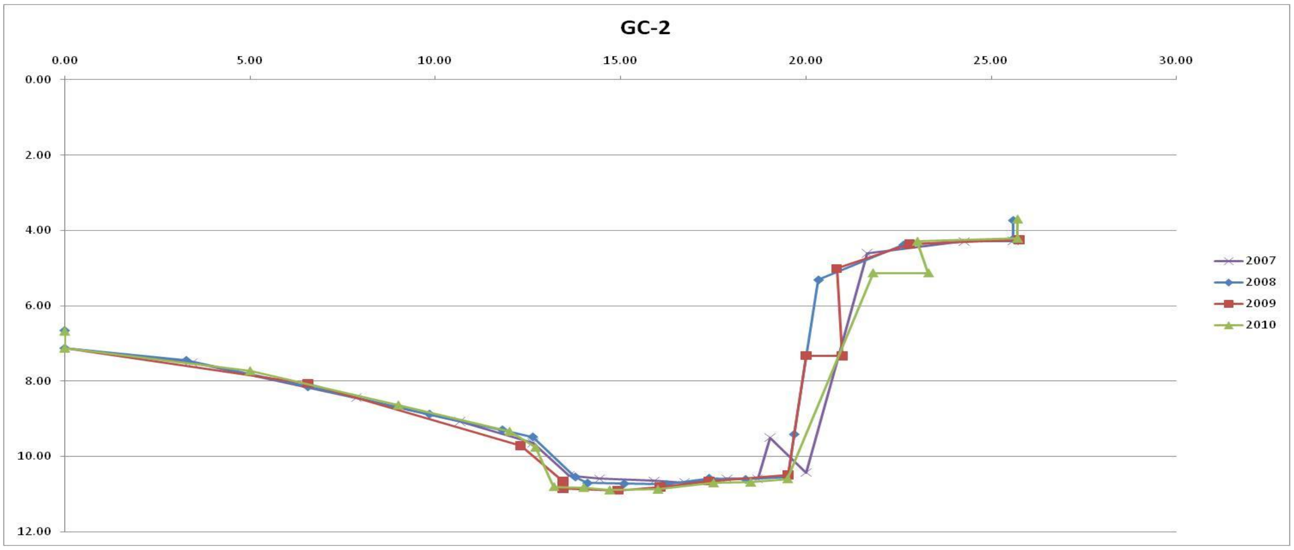
Land Use	2007		2004	
	Acres	% Area	Acres	% Area
Commercial	2.6	1.1	2.6	1.1
Open Space	4.0	1.7	4.0	1.7
Residential	101.9	43.3	100.9	42.8
Row Crops	21.5	9.1	21.5	9.1
Water	1.3	0.6	1.3	0.6
Woods	104.3	44.3	105.3	44.7
Total	**235.6**	**100.0**	**235.6**	**100.0**

Impervious Summary (2007)

Impervious Surface (acres)	Total Area Above Site	% Impervious
41.1	235.6	17.4

Habitat Conditions	**2010**	**2009**	**2008**	**2007**
EPA Narrative Rating	**Supporting**	**Partially Supporting**	**Supporting**	**Supporting**
Habitat Score	**143**	**115**	**138**	**128**
Bank Stability- Left Bank	4	1	3	3
Bank Stability- Right Bank	8	5	5	6
Channel Alteration	20	20	20	20
Channel Flow Status	17	9	19	17
Channel Sinuosity	18	14	15	11
Epifaunal Substrate/ Available Cover	11	11	13	14
Pool Substrate Characterization	8	9	10	8
Pool Variability	7	9	4	7
Riparian Vegetative Zone Width- Left Bank	10	10	10	10
Riparian Vegetative Zone Width- Right Bank	10	10	10	10
Sediment Deposition	15	10	11	12
Veg. Protection (Left Bank)	6	2	9	4
Veg. Protection (Right Bank)	9	5	9	6

Biological Conditions	**2010**	**2009**	**2008**	**2007**
Narrative Rating	**Fair**	**Poor**	**Poor**	**Very Poor**
BIBI Score	**3.00**	**2.43**	**2.14**	**1.86**
Metric Scores				
Total Taxa Score	5	5	5	3
EPT Taxa Score	5	3	3	3
Ephemeroptera Taxa Score	1	1	1	1
Intolerant Urban % Score	1	1	1	1
Ephemeroptera % Score	1	1	1	1
Scraper Taxa Score	5	1	1	1
% Climbers	3	5	3	3
Measured Metric Values				
Total Taxa	24	25	22	19
EPT Taxa	5	3	2	2
Ephemeroptera Taxa	0	0	0	0
Intolerant Urban %	0.8	0.9	2.9	0.0
Ephemeroptera %	0	0	0	0
Scraper Taxa	2	0	0	0
% Climbers	4.2	14.5	1.0	2.5



Geomorphic Conditions

Parameters	2007	2008	2009	2010
Bankfull Width (ft)	8.9	7.2	7.3	7.2
Mean Bankfull Depth (ft)	1.0	1.1	0.9	1.0
Floodprone Width (ft)	12.0	13.3	10.5	11.4
Entrenchment Ratio (ft./ft)	1.3	1.8	1.4	1.6
Width to Depth Ratio (ft/ft)	9.0	6.8	8.1	7.4
Cross Sectional Area (ft^2)	8.8	7.7	6.6	6.9
Slope (%)	0.54	0.65	0.52	0.56
Sinuosity (ft/ft)	1.6	1.5	1.4	1.7
D50 (mm)	0.15	0.14	0.37	0.50
Adjustments?	None	↓ER	None	↓ER
Rosgen Stream Type	**G5c**	**G5c**	**G5c**	**G5c**

DATA SUMMARY: GC-3

Upstream 2007

Upstream 2008

Upstream 2009

Upstream 2010

Site Coordinates: 38.80249° , 76.68627°

Location Description:
Off the service road on north side of MD Route 4, approximately 1200 feet south of Sands Road intersection, then approximately 120 feet NNE from the service road.

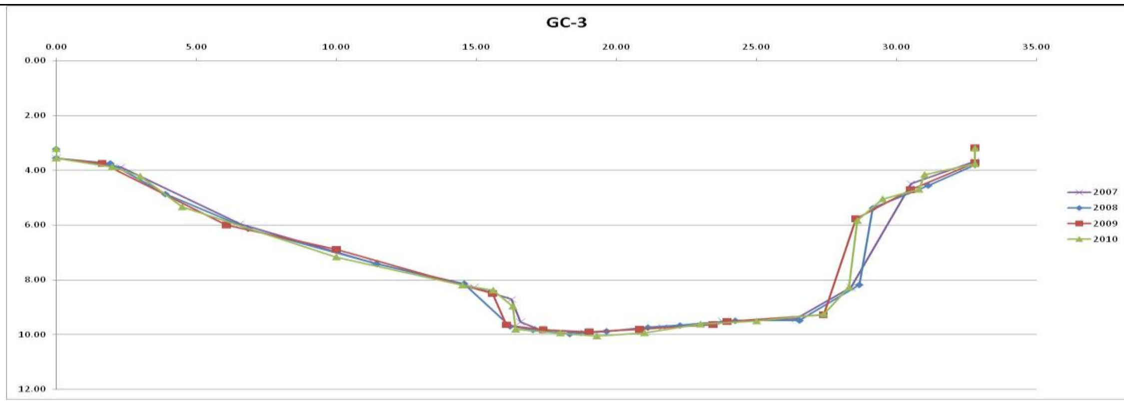
Land Use	2007		2004	
	Acres	% Area	Acres	% Area
Commercial	0.1	0.0	–	–
Open Space	15.3	3.0	15.3	3.0
Pasture/Hay	4.5	0.9	4.5	0.9
Residential	60.5	12.0	59.1	11.7
Row Crops	97.0	19.2	97.0	19.2
Transportation	30.8	6.1	30.8	6.1
Water	0.5	0.1	0.5	0.1
Woods	296.3	58.7	297.8	59.0
Total	**505.0**	**100.0**	**505.0**	**100.0**

Impervious Summary (2007)

Impervious Surface (acres)	Total Area Above Site	% Impervious
24.7	505.0	4.9

Habitat Conditions	2010	2009	2008	2007
EPA Narrative Rating	**Supporting**	**Non-supporting**	**Supporting**	**Partially Supporting**
Habitat Score	**139**	**95**	**129**	**121**
Bank Stability- Left Bank	6	8	7	6
Bank Stability- Right Bank	8	3	7	4
Channel Alteration	19	13	17	16
Channel Flow Status	15	9	15	17
Channel Sinuosity	10	6	8	5
Epifaunal Substrate/ Available Cover	13	11	19	15
Pool Substrate Characterization	10	8	10	10
Pool Variability	12	4	5	7
Riparian Vegetative Zone Width- Left Bank	8	4	1	8
Riparian Vegetative Zone Width- Right Bank	10	10	10	10
Sediment Deposition	12	8	17	13
Veg. Protection (Left Bank)	7	8	6	6
Veg. Protection (Right Bank)	9	3	7	4

Biological Conditions	2010	2009	2008	2007
Narrative Rating	**Poor**	**Good**	**Fair**	**Fair**
BIBI Score	**2.43**	**4.14**	**3.86**	**3.86**
Metric Scores				
Total Taxa Score	3	5	5	5
EPT Taxa Score	3	5	5	5
Ephemeroptera Taxa Score	1	3	3	3
Intolerant Urban % Score	5	5	5	3
Ephemeroptera % Score	1	3	3	3
Scraper Taxa Score	1	3	3	3
% Climbers	3	5	3	5
Calculated Metric Values				
Total Taxa	16	31	30	28
EPT Taxa	3	8	6	5
Ephemeroptera Taxa	0	1	1	1
Intolerant Urban %	65.3	60.4	52.9	24.1
Ephemeroptera %	0	20.7	1.9	0.9
Scraper Taxa	0	1	1	1
% Climbers	4.2	7.2	4.8	32.4



Geomorphic Conditions

Parameters	2007	2008	2009	2010
Bankfull Width (ft)	13.5	14.1	12.0	11.4
Mean Bankfull Depth (ft)	1.2	1.3	1.1	0.7
Floodprone Width (ft)	19.4	21.3	18.4	15.2
Entrenchment Ratio (ft./ft)	1.4	1.5	1.5	1.3
Width to Depth Ratio (ft/ft)	11.6	10.7	10.9	15.3
Cross Sectional Area (ft^2)	15.7	18.5	13.3	8.4
Slope (%)	0.86	0.87	0.62	0.67
Sinuosity (ft/ft)	1.0	1.1	1.0	1.0
D50 (mm)	0.40	0.24	5.1	10
Adjustments?	↑Sin	↑WD, ↑Sin	↑WD, ↑Sin	↑ER, ↑Sin
Rosgen Stream Type	**B5c**	**B5c**	**B4c**	**B4c**

Appendix B: Taxa List by Sample Station

GC-01	2007		2008		2009		2010		Grand Total	% Grand Total
Taxonomic Group	N	% Total	N	% Total	N	% Total	N	% Total		
Ablabesmyia	1	0.9			2	1.7			3	0.7
Acerpenna	3	2.7							3	0.7
Caecidotea	16	14.4	20	18.9	3	2.5	46	40.4	85	18.9
Chironomini	1	0.9							1	0.2
Chironomus	1	0.9	1	0.9			1	0.9	3	0.7
Corynoneura	1	0.9							1	0.2
Crangonyx	2	1.8							2	0.4
Dero	1	0.9	8	7.5					9	2.0
Dubiraphia	4	3.6	3	2.8	3	2.5	3	2.6	13	2.9
Helichus	1	0.9							1	0.2
Hyalella	3	2.7							3	0.7
Limnodrilus	2	1.8							2	0.4
Macronychus	6	5.4	5	4.7	6	5.1	4	3.5	21	4.7
Nais	3	2.7	3	2.8	5	4.2			11	2.4
Natarsia	1	0.9							1	0.2
Orthocladius/Cricotopus	39	35.1	1	0.9	7	5.9			47	10.5
Parakiefferiella	2	1.8							2	0.4
Paratanytarsus	1	0.9							1	0.2
Pentaneura	1	0.9							1	0.2
Polypedilum	7	6.3	4	3.8	25	21.2			36	8.0
Potthastia	1	0.9							1	0.2
Rheocricotopus	1	0.9							1	0.2
Rheotanytarsus	3	2.7	1	0.9	2	1.7			6	1.3
Spirosperma	1	0.9							1	0.2
Stempellinella	1	0.9							1	0.2
Stenelmis	1	0.9	2	1.9	21	17.8	4	3.5	28	6.2
Stictochironomus	1	0.9							1	0.2
Tanytarsus	2	1.8	2	1.9	3	2.5			7	1.6
Thienemannimyia	3	2.7					1	0.9	4	0.9
Tubificinae	1	0.9							1	0.2
Thienemannimyia genus group			2	1.9	7	5.9			9	2.0
Tanytarsini			1	0.9					1	0.2
Tipula			1	0.9	1	0.8			2	0.4
Stylaria			18	17.0					18	4.0
Chaetogaster			30	28.3					30	6.7
Oecetis			1	0.9					1	0.2

GC-01	2007		2008		2009		2010		Grand	% Grand
Nanocladius			1	0.9					1	0.2
Microcylloepus			1	0.9					1	0.2
Ancyronyx			1	0.9	4	3.4	2	1.8	7	1.6
Bezzia/Palpomyia					4	3.4			4	0.9
Calopteryx					1	0.8			1	0.2
Chaetocladius					4	3.4			4	0.9
Cheumatopsyche					6	5.1			6	1.3
Cladotanytarsus					2	1.7			2	0.4
Cryptochironomus					2	1.7			2	0.4
Cryptotendipes					2	1.7			2	0.4
Diplocladius					1	0.8			1	0.2
Gammarus					1	0.8	6	5.3	7	1.6
Hydropsyche					2	1.7			2	0.4
Neoplasta					1	0.8			1	0.2
Phaenopsectra					1	0.8			1	0.2
Physidae					1	0.8			1	0.2
Planorbidae					1	0.8			1	0.2
Baetis							1	0.9	1	0.2
Chironomidae							1	0.9	1	0.2
Cricotopus							27	23.7	27	6.0
Orthocladiinae							1	0.9	1	0.2
Orthocladius							13	11.4	13	2.9
Parametriocnemus							1	0.9	1	0.2
Tvetenia							3	2.6	3	0.7
Grand Total	**111**	**100.0**	**106**	**100.0**	**118**	**100.0**	**114**	**100.0**	**449**	**100.0**

GC-2	2007		2008		2009		2010		Grand Total	%Grand Total
Taxonomic Group	N	% Total	N	% Total	N	% Total	N	% Total		
Ablabesmyia	1	0.8	1	1.0	1	0.9			3	0.7
Amphinemura							1	0.8	1	0.2
Ancyronyx	2	1.7	4	3.8	1	0.9			7	1.5
Brillia			1	1.0	2	1.7	6	5.1	9	2.0
Ceratopogon			3	2.9	1	0.9			4	0.9
Ceratopsyche							1	0.8	1	0.2
Chaetocladius					3	2.6			3	0.7
Chaetogaster			5	4.8					5	1.1
Cheumatopsyche	1	0.8	1	1.0	8	6.8	4	3.4	14	3.0
Corynoneura					1	0.9	2	1.7	3	0.7
Cricotopus							1	0.8	1	0.2

GC-2	**2007**		**2008**		**2009**		**2010**		Grand	%Grand
Cryptochironomus			1	1.0					1	0.2
Culicoides			1	1.0					1	0.2
Dero	3	2.5							3	0.7
Diamesa	1	0.8					1	0.8	2	0.4
Diplocladius			2	1.9	1	0.9			3	0.7
Dubiraphia	10	8.3	8	7.6	3	2.6	4	3.4	25	5.4
Enchytraeidae							1	0.8	1	0.2
Eukiefferiella	3	2.5	1	1.0			2	1.7	6	1.3
Gammarus							4	3.4	4	0.9
Haplotaxis	1	0.8							1	0.2
Hemerodromia					2	1.7			2	0.4
Hydropsyche			1	1.0	9	7.7	1	0.8	11	2.4
Ironoquia	1	0.8			1	0.9	6	5.1	8	1.7
Labrundinia			1	1.0					1	0.2
Libellulidae							1	0.8	1	0.2
Lumbriculidae					2	1.7			2	0.4
Macronychus			2	1.9	1	0.9			3	0.7
Naididae							24	20.3	24	5.2
Nais	26	21.7	3	2.9	4	3.4			33	7.2
Nanocladius	1	0.8							1	0.2
Nemata			1	1.0	3	2.6			4	0.9
Nematoda	3	2.5							3	0.7
Orthocladiinae							2	1.7	2	0.4
Orthocladius							29	24.6	29	6.3
Orthocladius/Cricotopus	57	47.5	63	60.0	26	22.2			146	31.7
Paratendipes			1	1.0					1	0.2
Phaenopsectra					3	2.6			3	0.7
Pisidiidae			1	1.0					1	0.2
Pisidium					1	0.9			1	0.2
Polypedilum	2	1.7	1	1.0	11	9.4	5	4.2	19	4.1
Rheocricotopus							1	0.8	1	0.2
Rheotanytarsus					3	2.6			3	0.7
Slavina	3	2.5							3	0.7
Sphaerium							1	0.8	1	0.2
Stenelmis	2	1.7	2	1.9	21	17.9	4	3.4	29	6.3
Tanytarsus	1	0.8			6	5.1			7	1.5
Thienemanniella							1	0.8	1	0.2
Thienemannimyia	1	0.8					6	5.1	7	1.5
Thienemannimyia genus group					2	1.7			2	0.4
Tipula	1	0.8	1	1.0	1	0.9			3	0.7

GC-2	**2007**		**2008**		**2009**		**2010**		Grand	%Grand
Tubificidae							7	5.9	7	1.5
Tvetenia							3	2.5	3	0.7
Grand Total	**120**	**100.0**	**105**	**100.0**	**117**	**100.0**	**118**	**100.0**	**460**	**100.0**

GC-03	2007		2008		2009		2010		Grand Total	% Grand Total
Taxonomic Group	N	% Total	N	% Total	N	% Tot.	N	% Tot.		
Acerpenna	1	0.9	2	1.9	23	20.7			26	5.9
Amphinemura	14	13.0	16	15.4	13	11.7	62	52.5	105	23.8
Ancyronyx			1	1.0					1	0.2
Aulodrilus			1	1.0					1	0.2
Caecidotea	3	2.8					1	0.8	4	0.9
Ceratopogon			1	1.0					1	0.2
Chaetocladius	1	0.9	4	3.8	1	0.9			6	1.4
Chrysops			1	1.0	1	0.9			2	0.5
Cordulegaster	1	0.9							1	0.2
Diamesa	1	0.9							1	0.2
Diplectrona			1	1.0	1	0.9	2	1.7	4	0.9
Diplocladius			1	1.0	2	1.8			3	0.7
Dixella					1	0.9			1	0.2
Dubiraphia			1	1.0					1	0.2
Enchytraeidae					1	0.9			1	0.2
Eukiefferiella	3	2.8	8	7.7					11	2.5
Gammarus	9	8.3	6	5.8	2	1.8	22	18.6	39	8.8
Haploperla	2	1.9	29	27.9	21	18.9	10	8.5	62	14.1
Hemerodromia	2	1.9	2	1.9					4	0.9
Heterotrissocladius			1	1.0	2	1.8			3	0.7
Hexatoma							2	1.7	2	0.5
Hydrobaenus			2	1.9					2	0.5
Hydroporini						0.0	1	0.8	1	0.2
Isoperla					2	1.8			2	0.5
Micropsectra	2	1.9							2	0.5
Microtendipes					1	0.9			1	0.2
Nais	4	3.7							4	0.9
Nematoda	1	0.9							1	0.2
Neophylax	1	0.9	2	1.9	1	0.9			4	0.9
Neoplasta					1	0.9			1	0.2
Orthocladiinae	1	0.9							1	0.2
Orthocladius							5	4.2	5	1.1
Orthocladius/Cricotopus	16	14.8	3	2.9	1	0.9			20	4.5
Parametriocnemus	1	0.9	4	3.8	5	4.5			10	2.3
Paranemoura					1	0.9			1	0.2
Paratanytarsus					1	0.9			1	0.2
Phaenopsectra	1	0.9			2	1.8			3	0.7
Pisidium					3	2.7	1	0.8	4	0.9
Polycentropus			1	1.0					1	0.2

GC-03	2007		2008		2009		2010		Grand Total	% Grand Total
Polypedilum	28	25.9	1	1.0	8	7.2	4	3.4	41	9.3
Prosimulium	1	0.9	1	1.0					2	0.5
Prostoma			2	1.9					2	0.5
Pycnopsyche	1	0.9							1	0.2
Rheocricotopus	1	0.9	1	1.0					2	0.5
Rheotanytarsus	2	1.9	1	1.0	4	3.6			7	1.6
Simuliidae			2	1.9	2	1.8			4	0.9
Simulium	1	0.9			1	0.9	1	0.8	3	0.7
Stegopterna	1	0.9			1	0.9			2	0.5
Tanytarsus	5	4.6	4	3.8			1	0.8	10	2.3
Thienemanniella	1	0.9	1	1.0					2	0.5
Thienemannimyia									0	0.0
Thienemannimyia genus group			2	1.9	4	3.6			6	1.4
Tipula					1	0.9	2	1.7	3	0.7
Tubificidae							3	2.5	3	0.7
Tubificinae			2	1.9				0.0	2	0.5
Tvetenia	3	2.8			2	1.8	1	0.8	6	1.4
Wormaldia					1	0.9			1	0.2
Zavrelimyia					1	0.9			1	0.2
Grand Total	**108**	**100.0**	**104**	**100.0**	**111**	**100.0**	**118**	**100.0**	**441**	**100.0**