CHEMICAL, BIOLOGICAL, AND PHYSICAL CHARACTERIZATION OF THE CHURCH CREEK AND PAROLE PLAZA NPDES MONITORING STATIONS: 2013 - 2014

Prepared for

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1 INTRODUCTION

In 1998, Anne Arundel County began implementing a long-term monitoring program that satisfies requirements for its Countywide National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System Discharge Permit. Monitoring has continued to be required as part of the terms of each renewed permit. Currently, monitoring is required to satisfy conditions outlined in Section F: Assessment of Controls of the County's new permit issued in February 2014. The monitoring program includes chemical, biological, and physical monitoring in the Church Creek subwatershed located within the larger South River watershed. This document describes the monitoring effort undertaken from July 2013 through June 2014.

Biological and physical monitoring take place at monumented locations along the study reach, as described in more detail below. The chemical monitoring activities take place at two stations in the Church Creek subwatershed:

- Downstream of two high-imperviousness, commercial land use outfalls, called the Parole Plaza monitoring station
- An instream station downstream of the Route 2 culvert, called the Church Creek monitoring station

The basic permit requirements for storm event monitoring include sampling a target of 12 storms per year (three in each quarter) that are characterized by three representative (rising, peak, and falling limbs of the hydrograph) discrete samples per storm event, the collection of baseflow samples during extended dry periods, laboratory analysis of water quality parameters specified in the permit, biological and physical characterizations of the study reach, and continuous flow monitoring.

The County is interested in determining the extent to which the redevelopment of the Parole Plaza site (now known as the Annapolis Towne Centre at Parole) has affected the quality of the stormwater effluent from the site. Construction began in 2004, and the bulk of the site work was completed in late 2008.

2 METHODS

2.1 CHEMICAL MONITORING

During the 2014 sampling period, July 2013 through June 2014, seven storm events were sampled and five baseflow samples were collected and analyzed. This section describes the equipment and techniques used in this sampling program. It includes discussions of sample collection, sample analysis, flow data collection, and basin rainfall characterization. A summary of maintenance activities is also included. Data and quarterly data reports (Versar, Inc., 2014a, 2014b, and 2014c) were used to prepare this annual summary report.

2.1.1 Monitoring Sites

The long-term chemical monitoring program is performed at one outfall station, Parole Plaza, and one instream station, Church Creek. The two stations are described below:

Parole Monitoring Station. This station is a restoration station located at the head of the Parole Tributary to Church Creek. There are two outfalls draining to the sampling station. The first is a 60” corrugated metal pipe (CMP) that has been the historical sampling location for the monitoring of this station. The second is a 54” reinforced concrete pipe (RCP) that was connected to the drainage network during the summer of 2007.

Church Creek Monitoring Station. This station is an instream station on the mainstem of Church Creek. It is located approximately 500 feet downstream of the confluence of the tributary that carries the runoff from the Parole Plaza monitoring station. The samples are collected in the 96” CMP culvert that carries Church Creek underneath Maryland State Highway 2 (Solomons Island Road). Currently, the bottom of this culvert is lined with concrete that extends 1.8 feet in height up the sides of the corrugated metal culvert.

Location information and land use data were taken from the *Annapolis Towne Centre @ Parole Stormwater Management Report* (Greenhorne & O’Mara 2005), and summarized for each site in Tables 2-1 and 2-2.

Table 2-1. Drainage areas and site locations of monitoring stations in Church Creek watershed

Monitoring Station	Station Type	Location	Area (acres)
Parole Plaza	Restoration/Outfall	Southwest corner of Forest Drive and MD State Highway 2	60.41
Church Creek	Instream	Downstream (east) of MD State Highway 2	279.09

Table 2-2. Land use summary for the monitoring stations in the Church Creek subwatershed				
Land Use	**Land Use Area (acres)**		**Percent of Total Acreage**	
	Parole Plaza	**Church Creek**	**Parole Plaza**	**Church Creek**
Impervious	52.81	191.37	87.4	68.6
Open Space	7.60	87.72	12.6	31.4
TOTAL	**60.41**	**279.09**	**100**	**100**

2.1.2 Water Sample Collection and Data Analysis

The sample period for this reporting cycle extended from July 2013 through June 2014. Samples are analyzed for the presence of the pollutants listed in Table 2-3.

Table 2-3. Analytes, detection limits, and analytical methods for the Church Creek and Parole Plaza Monitoring stations		
Parameter	**Detection Limit (mg/L)**	**Analytical Method**
Biochemical Oxygen Demand (5 Day)	4.0	SM 5210 B-01
Total Kheldahl Nitrogen	0.5	SM 4500-NH3 C97
Nitrate + Nitrite	0.05	SM 4500-NO3 H00
Total Phosphorus	0.01	SM 4500-P E99
Total Suspended Sediments	1.0	SM 2540 D-97
Total Copper	0.002	EPA 200.8
Total Lead	0.002	EPA 200.8
Total Zinc	0.02	EPA 200.8
Total Petroleum Hydrocarbons	5.0	EPA 1664
E. coli (MPN/100 ml)	10.0	SM 9223B
Hardness	1.0	SM 2340 C

During the sampling period, seven storm samples and five baseflow samples were collected. Baseflow samples were taken in lieu of storm samples for the following reasons:

- August 28, 2013 - Versar field staff set up to monitor the storm event, but only 0.02” of rain fell. Since it was the end of the second month of the summer quarter with no successful events captured, and there had been less than 0.05” of rain that day, baseflow samples were collected instead. At time of arrival (late morning), Church Creek was exhibiting baseflow conditions and Parole Plaza had a small discharge from both pipes. It had rained 0.02 inches earlier in the day, thus providing enough water to represent the CMP in the baseflow sample. Since both pipes had approximately 0.02 feet of level, a 50 percent composite was collected at both sites. A baseflow sample was collected from Church Creek as well.

- September 27, 2013 - Total rainfall for the month of September was 1.99", which is below average. Rainfall in September primarily occurred on September 12 which was a monitored storm event and on September 22 when no staff were available to monitor the storm. With only a few days left in September, field staff obtained a baseflow sample to represent the September event. Versar personnel arrived at the sites at approximately 10:30 a.m. At the time of arrival, Church Creek was exhibiting baseflow conditions and Parole Plaza had a small discharge coming from the 54" RCP outfall; the 60" CMP was dry. A baseflow sample was collected from Church Creek and the 54" RCP outfall at Parole Plaza.

- March 6, 2014 - Rainfall amounts which included rain, snow, wintry mix, and snow melt for the months of January, February, and March totaled 9.72." During January, there was snowfall on January 3 followed by rain on January 5 which aided in melting the snow. The 72-hour dry time allowed Versar to attempt monitoring a storm on January 11 but was not successful. After January 11 a runoff event (either rain, snow or snow melt) took place every other day, which did not permit staff to attempt another monitoring event until February 3 (which also was unsuccessful). Several snow events, snow melts, and false starts for storm and baseflow sample collection took place in February; however, as of March 6 there had been no sample collection for the winter quarter. Therefore, Versar staff decided to collect baseflow samples from each site on March 6. Versar personnel arrived at the sites at approximately 11:00 a.m. At the time of arrival, Church Creek was exhibiting baseflow conditions with a level of 0.640 feet. However Parole Plaza was not exhibiting "normal" baseflow conditions; both pipes had a small amount of discharge. A baseflow sample was collected from Church Creek and a composite sample was collected from the 54" RCP outfall and the 60" CMP outfall at Parole Plaza. The 54" RCP outfall level was 0.04 feet and the 60" CMP outfall level was 0.01 feet; therefore, 80% of the sample volume came from the 54" RCP outfall and 20% of the volume came from the 60" CMP outfall.

- March 18, 2014 - With only a half of a month left in the quarter, another false start occurring on March 12, and more snow on March 16, field staff obtained a second set of baseflow samples to represent the winter quarter. Even though the snow event took place two days before, the temperatures were cold enough that there wasn't appreciable snow melt at the time of sample collection. Versar personnel arrived at the sites at approximately 2:00 p.m. to collect the samples. At the time of arrival, Church Creek was exhibiting baseflow conditions with a level of 0.640 feet. However, Parole Plaza was not exhibiting "normal" baseflow conditions; both pipes had a small amount of discharge. A baseflow sample was collected from Church Creek and a composite sample was collected from the 54" RCP outfall and the 60" CMP outfall at Parole

Plaza. The 54” RCP outfall level was 0.06 feet and the 60” CMP outfall level was 0.10 feet; therefore, roughly 40% of the sample volume came from 54” RCP outfall and 60% of the volume came from the 60” CMP outfall.

- March 28, 2014 - Rain was predicted for Friday March 28 and the entire weekend. A Versar field crew prepared to sample the smaller event on Friday since the event over the weekend was forecast to be well-above the duration time upper limit of 16.5 hours. Versar arrived at the site at approximately 10 a.m. to prepare for sampling. At approximately 1 p.m. Versar’s weather staff notified the field team that the last of the rain was coming through the Annapolis area. Unfortunately, the amount was less than the minimum criterion of 0.1 inches of rain; therefore, no storm sampling took place. Since it was at the end of the month and the rainfall did not exceed the 0.05” requirement for dry time, Versar collected baseflow samples. At 1:35 p.m., Church Creek was exhibiting baseflow conditions with a level of 0.605 feet. However Parole Plaza was not exhibiting “normal” baseflow conditions; both pipes had a small amount of discharge. A baseflow sample was collected from Church Creek and a composite sample was collected from the 54” RCP outfall and the 60” CMP outfall at Parole Plaza. The 54” RCP outfall level was 0.07 feet and the 60” CMP outfall level was 0.08 feet; therefore, roughly 50% of the volume comprising the sample was obtained from each pipe.

Below is a discussion of the storm events that were sampled during the monitoring period. Additional discussion of each event can be found in Appendix A.

- September 12, 2013 - The total rainfall for this event was 0.84” and lasted approximately 2 hours, based on data from the Church Creek rain gauge.

- October 7, 2013 - The total rainfall for this event was 0.64” and lasted approximately 7 hours, based on data from the Church Creek rain gauge.

- December 6, 2013 - This storm represents the November storm event since Versar staff were not able to sample the November 26th storm due to the holiday weekend. The total rainfall for this event was 0.61” and lasted approximately 10 hours, based on data from the Church Creek rain gauge.

- December 23, 2013 - The total rainfall for this event was 0.43” and lasted approximately 12 hours, based on data from the Church Creek rain gauge.

- April 7, 2014 - The total rainfall for this event was 0.29” and lasted approximately 12 hours, based on data from the Church Creek rain gauge.

- May 27, 2014 - The total rainfall for this event was 0.58” and lasted approximately 3 hours, based on data from Weather Underground weather station KMDANNAP17, which is located in Broad Creek, MD. This gauge was used because the ISCO that is connected to the rain gauge at the Church Creek station had no power during the event, therefore temperature, conductivity, pH, and rainfall was not continuously recorded. At the Church Creek station, pH and conductivity were measured using an *In situ* from the Parole Plaza station after the samples were collected; however, temperature was not measured due to the likely change in the water sample temperature after being stored outside of the stream for an extended period of time.

- June 19, 2014 - The total rainfall for this event was 0.23" and lasted approximately 3 hours, based on data from the Church Creek rain gauge.

A total of 37.93 inches of precipitation was recorded at the Church Creek Station during the 2014 reporting period. This does not include any rainfall that occurred while the station was powered down during late May and early June. Rainfall was measured using a tipping bucket rain gage located at the Church Creek Station. Table 2-4 lists the total rainfall for each sampled event. Hydrographs are provided in Appendix A. These data, along with stream level readings collected at 5 minute intervals from a permanently mounted pressure transducer, were logged into an ISCO 6712FR automated sampler.

Table 2-4. Rainfall data for sampled storm and baseflow events

Date	Rainfall (inches)
28 August 2013	0.00 (Baseflow)
12 September 2013	0.84
27 September 2013	0.00 (Baseflow)
7 October 2013	0.64
6 December 2013	0.61
23 December 2013	0.43
6 March 2014	0.00 (Baseflow)
18 March 2014	0.00 (Baseflow)
28 March 2014	0.00 (Baseflow)
7 April 2014	0.29
27 May 2014	0.58
19 June 2014	0.23

The ISCO sampler located at the Church Creek station is configured to hold 24 one-liter polyethylene bottles, and can be used to collect samples directly from the 96" CMP. However, this station is generally manned for the entire duration of each event. Therefore, samples are typically taken as grabs from the culvert outfall. Total petroleum hydrocarbon and *E. coli* samples are always collected as manual grab samples. The grab sample location is approximately six feet downstream of the intake for the automated sampler and samples should be equivalent in concentrations. When personnel leave the site during an event, the sampler is programmed to collect discrete, four-bottle (four-liter) samples at fixed time intervals. These intervals are based upon observations of the unique storm response characteristics of each watershed and the anticipated event duration to ensure that samples are distributed to characterize the typical storm as accurately as possible.

When the 54” RCP came online at Parole Plaza in the summer of 2007, portions of the drainage that had historically been passing through the 60” CMP began flowing through the new pipe. In order to maintain consistency in the characterization of the watershed, it was determined that samples were required from both pipes. Pressure transducers were permanently mounted in the 60” CMP and 54” RCP. These measured flow depth at 5-minute intervals, and stored data for up to three months. Data were downloaded bi-weekly. Stage/discharge relationships were prepared for each pipe, to determine the discharge from the pipes based on field-measured depths. The relationships were based on a combination of field measurements and modeled values. The model was necessary in order to characterize major storm events where measured values were not currently available. The rating tables are included in Appendix A.

A spreadsheet was developed to allow the field sampling crews to input field-measured level data. The spreadsheet interpolated the corresponding flow from the rating curves developed as described above. The flows from the 60” CMP and the 54” RCP were totaled and the resulting combined hydrograph for each event was plotted real-time. This method allowed the field crews to determine when the rising, peak, and falling limbs for the combined hydrograph occurred. The spreadsheet also calculated the percentage of the combined flow that each pipe was contributing. Using volumetric containers, the sampling team prepared composite samples using these percentages, and distributed them to the sample containers. A Technical Memorandum describing the sampling procedures in detail was submitted to the Maryland Department of the Environment in May 2008, and is included in Appendix A.

Water quality instruments for measuring pH, temperature, and conductivity were used at both stations. At Parole, an In-Situ Troll 9500 unit mounted within each pipe was used to obtain measurements during storm events; providing measurements every 5 minutes. Measurements for these parameters were not available when personnel were not present due to the low flow conditions at this station. Permanently installed probes would likely dry out and need to be replaced often, thus these units are engaged only during storm events. At the Church Creek Station, a YSI 600 XL multiparameter sonde was permanently mounted within the culvert and was connected directly to the ISCO automated sampler; providing measurements every 5 minutes. This unit operates continuously.

Samples were distributed into bottles provided by Martel Laboratories JDS, Inc., and Chesapeake Environmental Lab, Inc. All *E. coli* samples were delivered to the Chesapeake Environmental Lab for processing within six hours of being collected, and all other samples were delivered to Martel Laboratories JDS within 48 hours.

Event Mean Concentrations (EMCs) for each parameter were calculated for each storm and applied to total stormflow discharges to calculate stormflow pollutant loads for each site. An EMC is a statistical parameter used to represent the flow-weighted average concentration of a given parameter during a storm event (USEPA 2002). The EMC for a storm event where discrete samples have been collected (i.e., samples collected during the rise, peak, and falling limb of a storm event), was calculated using the following formula:

$$EMC = \frac{\sum_{i=1}^{n} V_i C_i}{\sum_{i=1}^{n} V_i}$$

where,

V: volume of flow during period *i*, which is determined from the interval associated with the samples collected during each limb
C: analytical result associated with period *i*
n: total number of limbs taken during event

The stormflow pollutant load for each parameter was calculated as:

$$Load = EMC_j V_j$$

where,

V: total volume of flow during period *j* (entire storm event).

Average annual EMCs were calculated by taking the arithmetic average of separate EMCs calculated when non-detects were set to zero and when non-detects were set to the detection limit. Since the true concentration of non-detect samples falls somewhere between the detection limit and the null value, this calculation represents a more accurate estimate than using EMCs with non-detects set to either zero or the detection limit. Seasonal loads (also referred to as quarterly loads) for monitored events were calculated by summing all monitored event loads for a specific season. Total seasonal loads were calculated by multiplying the average seasonal EMC by the total volume for the season. Annual loads were calculated by summing all seasonal loads.

2.1.3 Monitoring Station Maintenance

Maintenance was conducted at each sampling station on a biweekly basis. Maintenance included calibration of all probes, inspection of the sampling equipment, intake lines, and programming, and an overall cleaning and organization of the stations. A few issues concerning the replacement of monitoring equipment and the loss of data occurred during the monitoring period; below is a summary of these issues:

- On August 6, staff noticed the Global Water logger in the RCP at Parole Plaza was reading negative numbers frequently and therefore scheduled a calibration visit. On September 12, staff calibrated the logger before the storm event. During the storm event, field staff noted that the actual level as measured with a ruler was greater than the logger value. The day after the storm event, Versar staff noted that the logger was still reading negative numbers and calibrated the logger once again. At this time a tear in the logger's sensor wire was also noted and reported to Anne Arundel County.

After evaluating the problem, Versar and County staff agreed that a purchase of a new Global Water logger for this pipe was warranted.

ISCO sampler and Global Water WL-16 logger data were downloaded during each maintenance visit and were provided with the summer 2013 quarterly report (Versar 2014a) as Excel files "Church Creek Continuous Flow Data_07-09_13" and "Parole Plaza Continuous Flow Data_07-09_13." In the file labeled "Parole Plaza Continuous Flow Data_07-09_13" there is spreadsheet with raw data that shows the frequent occurrence of negative level values recorded by the malfunctioning logger in the RCP pipe. The columns in green are instances of satisfactory data collection. Yellow columns correspond to questionable data and red columns represent inaccurate data. Data in the yellow and red columns were replaced with corrected data that were calculated by applying a correction curve. The correction curve was prepared by plotting CMP level versus RCP level from storm events where both data sets were known to be correct. The corrected RCP data were obtained by using the correction curve equation, which was determined using a SAS curve-fitting program. Resulting RCP levels that were 0 or less were replaced with an assumed baseflow value of 0.02 ft. Included in these same files are the storm hydrographs for each site.

- County staff agreed that a purchase of a new Global Water logger for the RCP pipe was necessary; however, it was not installed until November 22 due to time needed to ship and calibrate the new equipment. Flow conditions prior to November 22 were estimated by applying a correction curve. However, during the storm of October 7, field staff noted the actual level with a ruler during sample collections to make a hydrograph. During several routine maintenance visits after the installation of the new logger, Versar staff noticed that the logger was reading 0.0 feet when physical measurements with the ruler showed 0.02 feet. After discussions with the County, Versar assigned a baseflow level reading of 0.02 feet for those instances where electronic level measurements of 0.0 feet were recorded. Subsequently, loggers were recalibrated to add a fixed offset of 0.02 feet for baseflow level readings.

- The Global Water logger in the CMP at Parole Plaza lost battery power on December 16 at 3:27; field staff replaced the batteries on December 22 at 22:31 before the storm. During an attempted January storm, data from the CMP and RCP files were accidently deleted by Versar staff, therefore no data are available for the remainder of the year (December 23 – 31).

- On January 8, the Global Water logger in the RCP at Parole Plaza was recalibrated to a fixed offset of 0.02 feet to represent normal baseflow level readings. During an attempted January storm, data from the CMP and RCP files were accidently deleted by Versar staff, therefore no data are available from December 23 – January 8. The Global Water logger in the CMP at Parole Plaza lost battery power on February 2 at 13:40. After trouble-shooting the problem the batteries were replaced on February 20 at 16:10. On February 28 at 1:00 until 12:20 and again that evening at 18:15 until the next day at 12:20, the Global Water logger in the CMP pipe recorded very high level readings because of low temperatures ranging from 34-36 degrees Fahrenheit (highlighted in red in the data file provided with the winter 2014 quarterly report (Versar 2014c)). Several times throughout the quarter at Church Creek, especially late night into the early hours of the morning, temperatures were low which caused the depth to fall below average level for the stream (*highlighted* in blue in the data file). During routine maintenance on January 29 at Church Creek, field staff noticed an inch of ice had accumulated on the top layer of the stream, which caused the level transducer to measure a level of -0.3 feet. Field staff broke up the ice and recalibrated the transducer to the correct level of 0.56 feet. The level transducer was inspected carefully during each visit thereafter for damage and to assure accuracy.

- On April 24 the global logger in the CMP at Parole Plaza was calibrated from 9:40 until 10:00 due to loss of calibration.

- Starting on May 26 the ISCO sampler at the Church Creek station began to have power issues, which caused it to lose data intermittently until May 27, when it completely lost power during a storm event. Manual readings were taken during the event in order to obtain a storm hydrograph. On June 5 the power was supplied by a battery; however, the technician accidently forgot to run the program, therefore no data was collected until Versar technicians visited the station for routine maintenance on June 11.

2.2 BIOLOGICAL MONITORING

All biological assessment data were collected in accordance with the Anne Arundel County Biological Monitoring and Assessment Program: Quality Assurance Project Plan (Anne Arundel County 2010), which incorporates many elements of Maryland Department of Natural Resources' Maryland Biological Stream Survey (MBSS). Geomorphic assessment data were collected in accordance with the standard operating procedures (SOPs) approved for the County's NPDES Program. All methods are consistent with previous years' methods (with applicable updates) to ensure data comparability between years. Collection methods are summarized below. Field data were collected in 2014 by Versar, Inc., a consultant to Anne Arundel County.

2.2.1 Sampling Locations

The study area is located in the northern portion of the Church Creek subwatershed, within the larger South River watershed in Anne Arundel County, Maryland (Figure 2-1). A total of four 75-meter biological monitoring sites are positioned along the study reach and are monitored annually. Three sites were established and first monitored in 2006; one site is located on the Parole Plaza Tributary just below Forest Drive, and two sites are located along the Church Creek mainstem, on either side of Solomons Island Road (Maryland State Highway 2). A fourth site, located just upstream of the confluence with the Parole Plaza Tributary, was added in 2007 to monitor the effects of runoff from the Festival at Riva shopping center.

2.2.2 Stream Habitat Evaluation

To support the biological monitoring, a visual assessment of physical habitat was completed at each monitoring site to evaluate the reach's ability to support aquatic life. Both the MBSS's Physical Habitat Index (PHI; Paul et al. 2003) and the EPA's Rapid Bioassessment Protocol (RBP) habitat assessment for high gradient streams (Barbour et al. 1999) were used to visually assess the physical habitat at each site in conjunction with the spring benthic monitoring. Both habitat assessments consist of a review of biologically significant habitat parameters that evaluate a stream's ability to support an acceptable level of biological health.

To calculate PHI at each site, six parameters were given a numerical score and a categorical rating: instream habitat, epibenthic substrate, remoteness, instream woody debris and rootwads, shading, and bank stability. The raw scores are then transformed into a scaled score (0-100 scale) as described in Paul et al. (2003), and the six scaled scores are averaged into an aggregate final PHI score. Narrative condition descriptions and scoring ranges for the PHI are displayed in Table 2-5.

Table 2-5. Maryland Biological Stream Survey PHI scoring

Score	Narrative
81-100	Minimally Degraded
66-80.9	Partially Degraded
51-65.9	Degraded
0-50.9	Severely Degraded

The Rapid Bioassessment Protocol (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: Epifaunal substrate/available cover, Embeddedness, Velocity/depth regime, Sediment deposition, Channel flow status, Channel alteration, Frequency of riffles/bends, Bank stability, Vegetative protection, and Riparian vegetative zone width. In the field, each parameter was given a numerical score from 0-20 (20=best, 0=worst), or 0-10 (10=best, 0=worst) for individual bank parameters, and a categorical rating of optimal, suboptimal, marginal or poor (Barbour et al. 1999). Overall habitat quality typically increases as the total score for each site increases. The individual RBP habitat parameters for each reach were summed to obtain an overall RBP assessment score. Because adequate reference conditions currently do not exist for Anne Arundel County, the percent comparability was calculated based on western coastal plain reference site conditions obtained from work done in Prince George's County streams (Stribling et al. 1999). The percent of reference score, or percent comparability score, was then used to place each site into corresponding narrative rating categories. The ranges are shown in Table 2-6.

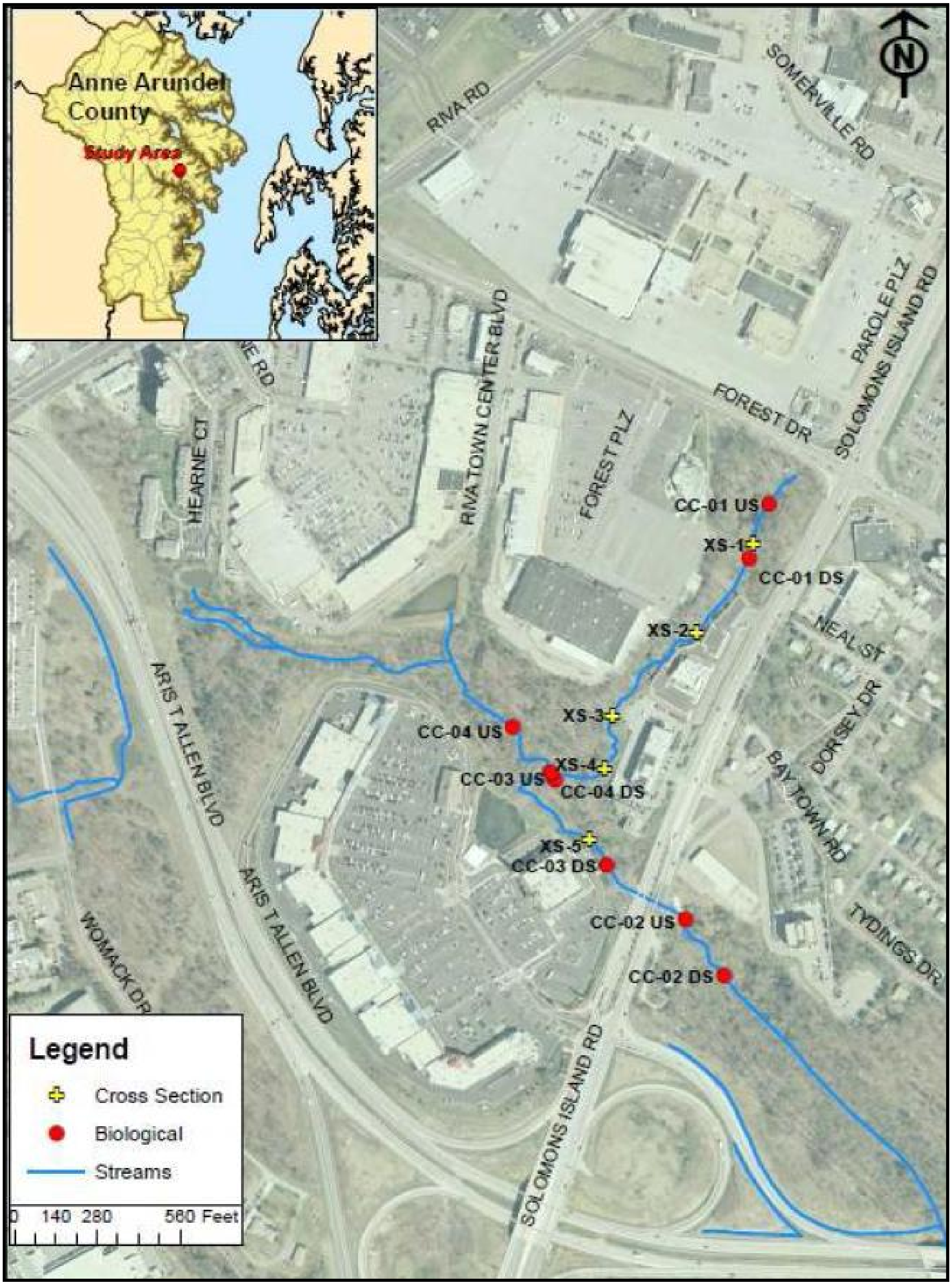

Figure 2-1. Church Creek study area and stream monitoring locations

Table 2-6. EPA Rapid Bioassessment Protocol (RBP) scoring	
Percent of Reference Score	**Narrative**
90 - 100	Comparable to Reference
75.1 - 89.9	Supporting
60.1 - 75	Partially Supporting
0 - 60	Non-Supporting

2.2.3 Water Quality Measurement

In situ water quality was measured at each site with a YSI 6820 multiparameter water quality sonde. Turbidity was measured once at the upstream end of the site, all other parameters were measured from three locations within each sampling reach (upstream end, mid-point, and downstream end) and results were averaged to minimize variability and better represent water quality conditions throughout the entire sampling reach. Data were compared to the standards listed in the Code of Maryland Regulations (COMAR) 26.08.02.03-3 – Water Quality (MDE, 2010) and shown in Table 2-7.

Table 2-7. Maryland COMAR Water Quality Standards for Use I Streams	
Parameter	**Standard**
pH	6.5 to 8.5
Dissolved Oxygen (mg/L)	Minimum of 5 mg/L
Conductivity (µS/cm)	No existing 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: Code of Maryland Regulations (COMAR) 26.08.02.03-3-Water Quality	

2.2.4 Biological Sample Collection

Benthic macroinvertebrate samples were collected in March 2014 following the MBSS Spring index period protocols (DNR, 2010) and as specified in *Anne Arundel County Biological Monitoring and Assessment Program: Quality Assurance Project Plan* (QAPP; Anne Arundel County 2010). This methodology emphasizes the community composition and relative abundance of benthic macroinvertebrates inhabiting the most taxonomically diverse, or productive, instream habitats. In this sampling approach, a total of twenty jabs are distributed among the most productive habitats present within the 75-meter reach and sampled in proportion to their occurrence within the segment. The most productive stream habitats are riffles followed by rootwads, rootmats and woody debris and associated snag habitat; leaf packs; submerged macrophytes and associated substrate; and undercut banks. Other less preferred habitats include gravel, broken peat, clay lumps and detrital or sand areas in runs; however, of the aforementioned habitat types, those that are located within moving water are preferred over those in still water.

2.2.5 Biological Sample Processing and Identification

Benthic macroinvertebrate samples were processed and subsampled according to Maryland Biological Stream Survey methods described in the MBSS laboratory methods manual (Boward and Freidman, 2000) and as briefly summarized in the Anne Arundel County Biological Monitoring and Assessment Program: Quality Assurance Project Plan (Anne Arundel County 2010). Subsampling is conducted to standardize the sample size and reduce variation caused by field collection methods. In brief, the sample was washed of preservative in a 0.595 mm screen and spread evenly across a tray comprised of 100 numbered 5cm x 5cm grids. A random number between one and 100 was selected and the selected gird was picked entirely of macroinvertebrates under a bright light source. This process was repeated until a count of 120 was reached. The 120 organism target was used following MBSS methods to allow for specimens that are missing parts or are early instars, which cannot be properly identified.

The samples were taxonomically identified by Versar taxonomists certified by the Society for Freshwater Science (SFS) (formerly known as the North American Benthological Society, NABS). The taxonomic hierarchical level for most organisms was genus level when possible with the exception of Oligochaeta, which were identified to the family level. Early instars or damaged specimens were identified to the lowest possible level. Oligochaeta and Chironomidae specimens were permanently slide mounted for identification. Counts and identifications were recorded on a laboratory bench sheet and entered into a master database for analysis. A list of all taxa identified is provided in Appendix B: Master Taxa List.

2.2.6 Biological Data Analysis

Benthic macroinvertebrate data were 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, composition measures, tolerance to perturbation, trophic classification, and habit measures. Tolerance values were obtained from Bressler et al. (2005).

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 ranging from 1.0 to 5.0 and a corresponding narrative rating is assigned. Table 2-8 shows the thresholds for the determination of the metric scoring. Three sets of metric calculations have been developed for Maryland streams based on broad physiographic regions: Coastal Plain, Piedmont and Combined Highlands. The Coastal Plain and Piedmont regions are divided by the Fall Line. The current study area is located within the Coastal Plain region. The metrics calculated for Coastal Plain streams are as follows:

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 **–** Percentage of sample considered intolerant to urbanization. Equals the percentage of individuals in the sample with a tolerance value of 0-3 out of 10. As impairment increases the percent of intolerant taxa decreases.

Percent Ephemeroptera – 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 – Equals the percentage of the total number of individuals who are adapted to living on stem type surfaces. Higher percentages of climbers typically represent a decrease in stressors and overall better water quality.

All of the metric scores are summed and then averaged to obtain the final BIBI score. Table 2-8 shows the scores and narrative rankings of the MBSS BIBI. The biological assessment results are included in Appendix C. The QA/QC information is included in Appendix D.

Table 2-8. Biological condition scoring for the coastal plains metrics

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	1.9-1.0	< 1.0
Percent Intolerant Urban	≥ 28	10-27	< 10
Percent Ephemeroptera	≥ 11	0.8-10.9	< 0.8
Number of Scraper Taxa	≥ 2	1.9-1.0	< 1.0
Percent Climbers	≥ 8.0	0.9-7.9	< 0.9

Table 2-9. Maryland Biological Stream Survey BIBI scoring		
BIBI Score	**Narrative Ranking**	**Characteristics**
4.0-5.0	Good	Comparable to reference conditions, stream considered to be minimally impacted, biological metrics fall within upper 50th percentile 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 10th 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 10th percentile of reference site values.

2.3 PHYSICAL MONITORING

2.3.1 Monitoring Sites

Five cross sections (XS), four of which were established in 2003 and one which was established in 2007, have been measured annually through 2014. Four of these cross sections are located along the Parole Plaza Tributary, and one cross section is located on the Church Creek mainstem, just upstream of Solomon's Island Road (Maryland State Highway 2; Figure 2-1). Cross section monuments, placed on each bank, consist of capped steel reinforcement bars set within six inches of the ground surface. Field data collected by Versar, Inc. during 2014 were used to prepare this annual summary report.

2.3.2 Physical Data Collection and Analysis

Geomorphic assessments include a longitudinal profile survey, cross section surveys, and representative pebble counts. A spreadsheet tool called *The Reference Reach Spreadsheet* version 4.3L (Mecklenburg 2006) was used to facilitate data entry and analyses. This spreadsheet was used to compile, manipulate, and plot field data and to analyze dimension, profile, and channel material characteristics of the Church Creek study area.

Data from geomorphic assessments were used to determine the stream type of each reach as categorized by the Rosgen Stream Classification methodology (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 E. As illustrated in Appendix E, the Rosgen Stream Classification categorizes streams into broad stream types, which are identified by the letters Aa, A, B, C, D, DA, E, F, and G. Table 2-10 includes general descriptions of each Rosgen stream type. A summary of the stream types identified within this study is included in Appendix F.

Table 2-10. Rosgen stream classification types

Channel Type	General Description
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 bedload 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 streambanks.
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.

Source: Rosgen, D. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, Colorado

The cross section surveys were performed at the five permanent cross section locations, and photos were taken of upstream, downstream, left bank, and right bank views at each cross section location. Cross section surveys consisted of measuring the topographic variability of the associated stream bed, floodplains, and terraces, including:

- Monument elevations
- Changes in topography
- Top of each channel bank
- Elevations of bankfull indicators
- Edge of water during the time of survey
- Thalweg or deepest elevation along active channel
- Depositional and erosional features within the channel

During the cross sectional survey, the following measurements and calculations of the bankfull channel, which are critical for determining the Rosgen 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 versus 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 versus bankfull width.
- Sinuosity (K): ratio of the stream length versus 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.

To quantify the distribution of channel substrate particles sizes within the study area, a modified Wolman pebble count (Rosgen 1996) was performed at each cross section location. Reach-wide proportional counts were used. Each pebble count consists of stratifying the reach based on the frequency of channel features in that reach (e.g., riffle, run, pool, glide) and measuring 100 particles across ten transects (i.e., 10 particles in each of 10 transects). The transects are allocated across all feature types in the proportion at which they occur within the reach. The intermediate axis of each measured pebble is recorded. The goal of the pebble count is to measure 100 particles across the bankfull width of the channel and calculate the median substrate particle size (i.e., D50) of the reach. This value is used for categorizing the sites into the Rosgen Stream Classification (Rosgen 1996). 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 variation in bed material size from feature to feature, a full pebble count was performed.

2.4 LAND USE AND STORMWATER MANAGEMENT ASSESSMENT

2.4.1 Church Creek Watershed Land Use

Versar (2013) had provided information on land use, based on inspections conducted during 2013. As seen on the 2013 Church Creek land use and BMP map (Figure 2-2), the watershed is predominantly commercial with open space area adjacent to the stream channels.

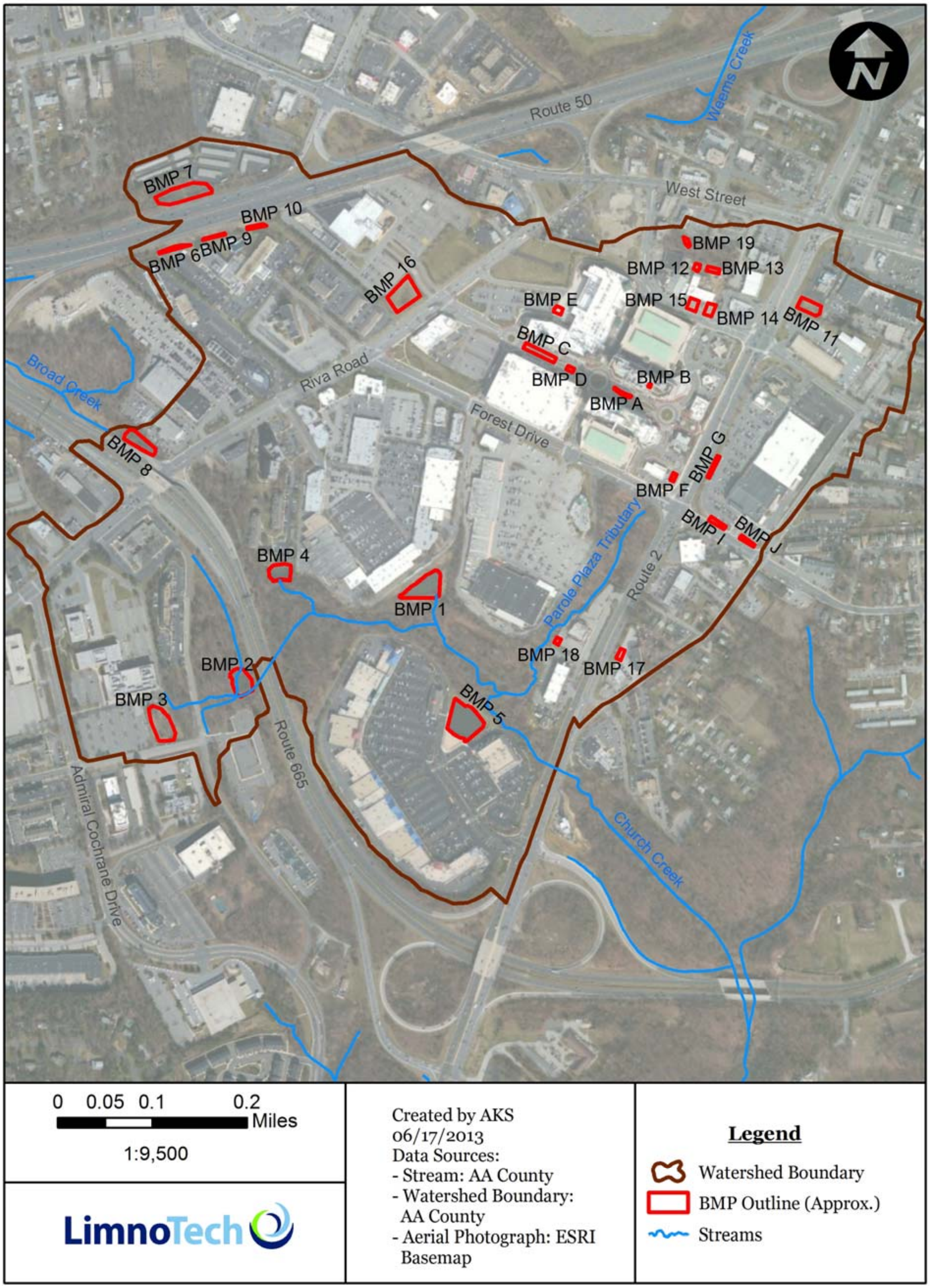

Figure 2-2. Church Creek BMPs (Figure from Versar 2013)

There is little available area for further development in the watershed except for areas that are being redeveloped. Anecdotal information indicates there has been no change in land use in this watershed since the 2013 land use evaluation. Changes in land use characteristics were not field evaluated during the 2014 reporting period.

2.4.2 Church Creek Watershed Stormwater BMPs

As of the 2013 evaluation, the Church Creek watershed contains 28 BMPs, as shown in Figure 2-2. BMP details are provided in Table 2-11. Anne Arundel County Department of Inspection & Permits conducted inspections of the County BMP facilities, located in this watershed, in July of 2014. The results of these inspections will be documented in the 2015 Annual Report.

Table 2-11. Church Creek BMP overview (Table from Versar 2013)

Church Creek BMP[(a)]	AA County Urban BMP Database ID	BMP Type[(b)]	Drainage Area (acres)[(c)]	Location	Address	Presumed Owner
1	AA001128	EDSW	26.95	Festival at Riva Shopping Center	Riva Road and Forest Drive	County
2	not found in 2012 database	DP	-	Forested Area	Between Aris T. Allen Boulevard and Womack Drive	SHA
3	AA000079	DP	14.6	ARINC Parking Lot	Spruill Road and Admiral Cochrane Drive	County
4	AA000074	DP	12.95	Forest Garden Apartments	130 Hearne Court	County
5	AA001042	EDSW	15.7	Annapolis Harbour Center	Solomons Island Road	County
6	Possibly AA010839	IB	0.4	Double Tree by Hilton Hotel Parking Lot	Route 50	SHA
7	AA001069	DP	9.7	Annapolis Self Storage	Route 50 near E Classic Ct	SHA
8	not found in 2012 database	IB	-	Sheehy Nissan of Annapolis	Aris T. Allen Blvd and Riva Road	SHA
9	Possibly AA010839	IB	0.4	Double Tree by Hilton Hotel Parking Lot	Route 50	SHA
10	Possibly AA010839	IB	0.4	Double Tree by Hilton Hotel Parking Lot	Route 50	SHA
11	AA001446	EDSD	1.9	Second National Federal Savings Bank	2045 West St.	City of Annapolis
12	AA012015	ESD SGW	0.25	AAA Mid Atlantic Car Care	2054 Somerville Road	County
13	AA012014	ESD PERMP	0.25	AAA Mid Atlantic Car Care	2054 Somerville Road	County
14	AA012013	ESD MB	0.25	AAA Mid Atlantic Car Care	2054 Somerville Road	County
15	AA012012	ESD MB	0.25	AAA Mid Atlantic Car Care	2054 Somerville Road	County
16	AA000071	EDSD	3.47	Nationwide Insurance	2453-2499 Riva Road	County
17	AA006493	ITPE	0.35	Annapolis Station	2431 Solomons Island Road	County
18	AA001180	ITPE	-	Two Restaurant Sites	2436 Solomons Island Road	County
19	not found in 2012 database	DP	-	Capitol One Bank	2200 Somerville Road	County
A	Possibly AA008471	BR	0.3	Annapolis Towne Center at Parole	Towne Center Boulevard	County

(a) Numbering system carried over from the 2012 BMP inspection report.
(b) BMP type copied from the AA County Urban BMP database. See List of Acronyms in Appendix H.
(c) Drainage areas copied from the 2012 BMP inspection report or from the 2012 AA County Urban BMP database. Some drainage areas are missing in the Urban BMP database.

Table 2-11. (Continued)

Church Creek BMP[a]	AA County Urban BMP Database ID	BMP Type[b]	Drainage Area (acres)[c]	Location	Address	Presumed Owner
B	Possibly AA008472	BS	0.53	Annapolis Towne Center at Parole	Towne Center Boulevard	County
C	Possibly AA008475	BR	0.4	Annapolis Towne Center at Parole	Towne Center Boulevard	County
D	Possibly AA008473	BS	1.88	Annapolis Towne Center at Parole	Towne Center Boulevard	County
E	Possibly AA008474	BS	6.41	Annapolis Towne Center at Parole	Towne Center Boulevard	County
F	Possibly AA008461 through AA008470 or AA009145	StormFilter	4.78	Annapolis Towne Center at Parole	2398 Solomons Island Road	County
G	not found in 2012 database	BR		Shoppers Food Warehouse	2371 Solomons Island Road	County
H	*There is no BMP H; please refer to the 2012 BMP inspection report for further explanation*					
I	not found in 2012 database	BR		Shoppers Food Warehouse	2104-3098 Forest Drive	County
J	not found in 2012 database	BR		Shoppers Food Warehouse	2100-2102 Forest Drive	County

3 RESULTS

3.1 POLLUTANT CONCENTRATIONS

During this sampling period, 52 water chemistry samples were analyzed. In a few instances, analyte concentrations fell below the specified detection limits. Table 3-1 shows the percentage of samples that were below the detection limit. TPH was only detected once during the 2014 reporting year. This occurred at the Parole Plaza monitoring station during the baseflow event sampled on March 18, 2014.

Table 3-1. The percentage of non-detects by parameter

Parameter	Detection Limit (mg/L)	Dry Weather	Wet Weather
BOD_5	4.0	60	26
TKN	0.5	30	29
Nitrate + Nitrite	0.05	0	2
Total Phosphorus	0.01	0	2
TSS	1.0	40	7
Total Copper	0.002	20	7
Total Lead	0.002	90	48
Total Zinc	0.02	10	2
TPH	5.0	90	100
E. coli (MPN/100 ml)	10.0	0	0
Hardness	1.0	0	2

Tables 3-2 and 3-3 show the maximum values observed for dry and wet weather samples for both stations. Table 3-4 shows the maximum value for each parameter during wet weather monitoring, the station of occurrence, and the storm date of the observation. Parole Plaza had the highest wet-weather value for seven of the twelve parameters detected during wet weather sampling in 2014. Chemical monitoring summaries can be found in Appendix G.

Table 3-2. Maximum dry weather values observed during sampling period		
Parameter	**Church Creek**	**Parole Plaza**
Water Temperature (°C)	22.2	21.98
pH	7.1	7.3
BOD_5 (mg/L)	4	10
TKN (mg/L)	5.60	3.80
Nitrate + Nitrite (mg/L)	1.90	6.70
Total Phosphorus (mg/L)	0.12	0.18
TSS (mg/L)	27	73
Total Copper (mg/L)	0.008	0.025
Total Lead (mg/L)	BDL	0.003
Total Zinc (mg/L)	0.091	0.180
TPH (mg/L)	BDL	6.0
E. coli (MPN/100 ml)	644	3,873
Hardness (mg/L)	220	260
BDL: Below Detection Limit		

Table 3-3. Maximum wet weather values observed during sampling period		
Parameter	**Church Creek**	**Parole Plaza**
Water Temperature (°C)	25.80	25.63
pH	7.45	7.87
BOD_5 (mg/L)	36	57
TKN (mg/L)	3.50	4.40
Nitrate + Nitrite (mg/L)	1.80	6.00
Total Phosphorus (mg/L)	1.00	0.42
TSS (mg/L)	190	250
Total Copper (mg/L)	0.092	0.068
Total Lead (mg/L)	0.017	0.010
Total Zinc (mg/L)	0.170	0.340
TPH (mg/L)	0.0	0.0
E. coli (MPN/100 ml)	29,090	68,670
Hardness (mg/L)	120	100
BDL: Below Detection Limit		

Table 3-4. Storm dates for wet weather maximum values			
Parameter	**Date of Storm**	**Site**	**Maximum Value**
Water Temperature (°C)	6/19/14	Church Creek	25.80
pH	4/7/14	Parole Plaza	7.87
BOD_5 (mg/L)	5/27/14	Parole Plaza	57
TKN (mg/L)	5/27/14	Parole Plaza	4.40
Nitrate + Nitrite (mg/L)	10/7/14	Parole Plaza	6.00
Total Phosphorus (mg/L)	9/12/13	Church Creek	1.00
TSS (mg/L)	12/23/13	Parole Plaza	250
Total Copper (mg/L)	5/27/14	Church Creek	0.092
Total Lead (mg/L)	5/27/14	Church Creek	0.017
Total Zinc (mg/L)	5/27/14	Parole Plaza	0.340
TPH (mg/L)	N/A	Both	BDL
E. coli (MPN/100 ml)	6/19/14	Parole Plaza	68,670
Hardness (mg/L)	9/12/13, 4/7/14	Church Creek	120
BDL: Below Detection Limit			

3.2 EVENT MEAN CONCENTRATIONS AND POLLUTANT LOADINGS

Flow-weighted stormflow event mean concentrations (EMCs) values are presented in Table 3-5. EMCs were equal between the two sites for TPH. EMCs for every parameter except total lead and hardness were higher at Parole Plaza than EMCs at Church Creek.

Summed loads for the sampled events monitored during the July 2013 to June 2014 sampling period are shown in Table 3-6. Church Creek per-acre loading rates for monitored events were higher than or equal to Parole Plaza for all parameters except nitrate-nitrite and total zinc.

Table 3-5. Average EMCs observed during July 2013 to June 2014		
Parameter	**Church Creek**	**Parole Plaza**
Water Temperature (°C)	17.36	19.18
pH	7.10	7.23
BOD_5 (mg/L)	3.53	4.33
TKN (mg/L)	0.590	0.772
Nitrate + Nitrite (mg/L)	0.332	0.575
Total Phosphorus (mg/L)	0.138	0.146
TSS (mg/L)	39.71	48.77
Total Copper (mg/L)	0.011	0.021
Total Lead (mg/L)	0.004	0.003
Total Zinc (mg/L)	0.066	0.120
TPH (mg/L)	2.5	2.5
E. coli (MPN/100 ml)	8,638.07	12,716.40
Hardness (mg/L)	38.32	38.18

Table 3-6. Estimated pollutant loadings for observed events, in pounds, for the July 2013 to June 2014 sampling period				
Parameter	**Church Creek**		**Parole Plaza**	
	Total	**Per Acre**	**Total**	**Per Acre**
BOD_5	924.15	3.31	159.50	2.64
TKN	154.45	0.55	28.44	0.47
Nitrate + Nitrite	86.79	0.31	21.20	0.35
Total Phosphorus	36.14	0.13	5.40	0.09
TSS	10,396.02	37.25	1,797.11	29.75
Total Copper	2.87	0.01	0.78	0.01
Total Lead	0.970	<0.01	0.102	<0.01
Total Zinc	17.338	0.06	4.412	0.07
TPH	654.417	2.34	92.126	1.53
Hardness	10,031.61	35.94	1,407.066	23.29

3.3 BIOLOGICAL ASSESSMENT

Biological and physical habitat assessments were completed on March 14, 2014. Presented below are the summary results for each assessment site. For full bioassessment data and results, refer to Appendix C. A complete taxonomic list can be found in Appendix B. QA/QC information is in Appendix D.

Physical habitat quality was evaluated using the MBSS PHI, and rated "Degraded" for three sites and "Partially Degraded" for one site (Table 3-7). Index scores varied somewhat and ranged from a low of 56.2 at CC-02 to a high of 70.8 at CC-03. All sites received very low scores for remoteness due to the proximity of the stream channel to roads and development. Generally, instream woody debris scored high for all the sites. Individual parameter results are listed in Appendix C. Overall, PHI scores throughout the study area indicate habitat conditions that are limiting the potential for healthy biological communities.

The RBP was also used to evaluate the physical habitat quality and rated "Partially Supporting" for three sites and "Supporting" for one site (Table 3-7). Index ranged from a low of 65 at CC-02 to a high of 81 at CC-03. Generally, epifaunal substrate/cover, embeddedness, velocity/depth regime, and vegetative protection scored low for all the sites. Overall, RBP scores throughout the study area indicate habitat conditions that are limiting the potential for healthy biological communities, similar to what was found using the PHI.

Table 3-7. PHI and RBP physical habitat assessment results - 2014

Site	PHI Score	PHI Narrative Rating	RBP Score	RBP Narrative Rating
CC-01	65.8	Degraded	70	Partially Supporting
CC-02	56.2	Degraded	65	Partially Supporting
CC-03	70.8	Partially Degraded	81	Supporting
CC-04	60.1	Degraded	70	Partially Supporting

For biological conditions, all four stations received a rating of "Very Poor", indicating a highly impaired benthic macroinvertebrate community. The number of individual benthic organisms collected in station CC-01 was 18, which is extremely low. Number of EPT taxa, Percent Intolerant Urban, Number of Ephemeroptera and Percent Ephemeroptera metrics scored low for all sites. Only the Percent Climbers metric received high scores for all sites. The lower than average temperature during March 2014 combined with the high conductivity values from salt treatment on road found at the sites likely contributed to the metrics being scored lower this year than in the past. BIBI scores and ratings are summarized in Table 3-8.

Table 3-8. Benthic macroinvertebrate assessment results - 2014

Site	BIBI Score	Narrative Rating
CC-01	1.57	Very Poor
CC-02	1.86	Very Poor
CC-03	1.29	Very Poor
CC-04	1.57	Very Poor

To supplement the biological assessment data, *in situ* water quality parameters were measured at each biological monitoring site prior to sample collection. Table 3-9 shows the water quality data for each site. All parameters measured were within Maryland's water quality standards for Use I streams. Conductivity values were very elevated compared to most coastal plain streams, and far exceeded the 75th percentile of values (i.e., 307 µS/cm) measured during Round One (2004-2008) of the Countywide Biological Monitoring and Assessment Program (Hill and Pieper, 2011). Conductivity values were relatively high compared to most coastal plain streams, as well as higher than the range of those found in other urban, or highly impervious, drainage areas in Maryland (DNR, 2001, 2003, 2005; KCI, 2009a; Hill and Crunkleton, 2009). Stream conductivity is affected by inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions or sodium, magnesium, calcium, iron, and aluminum cations, many of which are generally found at elevated concentrations in urban streams (Paul and Meyer, 2001). Increased stream ion concentrations (measured as conductivity) in urban systems typically results from runoff over impervious surfaces, passage through pipes, and exposure to other infrastructure (Cushman, 2006). In 2014, the greater than average snow amount caused the roads to be treated with salt more frequently than during an average year. This most likely caused the conductivity values to be higher.

Table 3-9. *In situ* water quality results - 2014

Site	pH	Temperature	Dissolved Oxygen	Turbidity	Conductivity
	SU	°C	mg/L	NTU	µS/cm
CC-01	6.73	9.84	9.4	21.7	3493
CC-02	7.09	3.08	11.03	15.2	3384
CC-03	6.87	5.17	8.97	14.8	3356
CC-04	6.69	7.41	11.01	19.5	3526

3.4 GEOMORPHIC ASSESSMENT

Due to the highly altered conditions of the drainage area (i.e., high imperviousness, altered flow regime, numerous stormwater outfalls) and stream channel (i.e., channelization, stabilization) in the study area, reliable bankfull indicators were often difficult to locate in the field. In the absence of reliable bankfull indicators, bankfull elevations were adjusted to match the predicted values for bankfull area provided by the bankfull channel geometry relationship for urban streams developed specifically for Anne Arundel County (AADPW 2002). Furthermore, categorization of segments into the Rosgen Classification scheme for natural rivers required a fair amount of professional judgment to interpret the data. When assigning the stream classification types, values for some parameters would often fit into the prescribed ranges according to the Rosgen Classification while others would not. Many of the features at the existing cross section locations have shifted from riffle features to pool features, which can skew the channel dimensions since classifications are based on riffle dimensions. Consequently, it was often necessary to apply best professional judgment and incorporate supplemental information (e.g., presence of depositional features) in order to assign the most appropriate stream classifications.

The most upstream reach on the Parole Plaza Tributary, XS-1, has been undergoing a transition from a Rosgen C4/5 channel to a F4/5 channel, as evidenced by changes in the width/depth and entrenchment ratios. Previous monitoring in 2010 suggested that this reach was shifting from an E to a C channel as evidenced by channel degradation along the right bank and a notable increase in sediment deposition and point bar formation along the right bank just downstream. Additional degradation between 2010 and 2012 suggest that the channel has lost connectivity to the floodplain and has likely shifted to an F stream type. In 2014, geomorphic assessment parameters continue to support the classification of this reach as an F channel. The channel evolution is supported by a 33% increase in channel cross-sectional area since 2003 and considerable widening and mid-channel bar formation immediately downstream, which is indicative of a channel that it not stable and is undergoing a widening and degradation phase. Left bank widening was also apparent between 2013 and 2014 monitoring years. However, it is also important to acknowledge that this cross section is no longer located in a riffle feature and is now in a pool feature, which affects the channel dimensions and complicates classification using the Rosgen system.

The next site downstream on the Parole Plaza Tributary, XS-2, was classified as a Rosgen G4c channel based on its low width/depth ratio, relatively low slope, and sandy substrate. Between 2013 and 2014 monitoring the substrate became slightly more course. Since 2012 its entrenchment ratio was slightly higher than those typical of G streams, but to retain consistency with the 2011 classification, the G rating was retained. The entrenchment ratio did however decrease from 1.7 to 1.6 between 2012 and 2014 which is comparable with G type streams given the continuum of physical variables of (+/- 0.2). This reach was previously classified as an E type channel; however, it was noted that the reach was actively degrading and widening. While E streams are typically more sinuous, this segment has been noticeably straightened and stabilized by a retaining wall and rubble/fill along the left bank (facing downstream). The lack of sinuosity in the channel has likely resulted in instability, and consequently resulted in a shift to a less-stable form.

Site XS-3, located along the restored segment of Parole Plaza Tributary, was not classified until 2013, after allowing 3 years of stabilization after restoration. In 2013 and 2014 it has been classified as a Rosgen G4c channel based on its low entrenchment ration, low width/depth ratio, and low slope. Before restoration, this cross section was classified as a Rosgen G5c channel; however, since the Rosgen scheme was developed to classify natural channels, or those that are shaped naturally by fluvial processes, it was deemed inappropriate to classify immediately after construction. This section is still heavily armored and reliable bankfull indicators are not easily identified.

The most downstream site on the Parole Plaza Tributary, XS-4, has transitioned from a Rosgen E5 channel to a C5 channel due to an increase in width/depth ratio. It should also be noted that a large woody debris jam located just downstream of the cross section location has resulted in a considerable accumulation of fine sediment and debris across the channel and, consequently, is leading to aggradation and a reduction in the cross sectional area. Since 2003 cross-sectional area has decreased by 52.4%.

Located on the mainstem of Church Creek, upstream of the MD Rt. 2 culvert, XS-5 has transformed from a Rosgen C3/5 channel into an F3 channel due to a significantly decreased entrenchment ratio from 4.0 to 1.6 between 2012 and 2014. Although still categorized as moderate, width/depth ratio has also decreased slightly. This segment shows evidence of previous alteration in the form of cobble-sized riprap armoring along the bed and lower banks to protect a sewer line crossing and obvious channel straightening, which explains the lack of sinuosity typical of F type streams. The substantial amount of cobble-sized rip-rap in the stream channel has resulted in a bi-modal distribution of substrate particles within this reach, with a predominance of gravel in the pools and artificial cobbles in the riffles.

4 DISCUSSION

Results from the July 2013-June 2014 study period are discussed in the following section. Water quality, biological, and geomorphological data are interpreted, presented and compared to previous data. A discussion of the characteristics of the watershed is also included.

4.1 WATER CHEMISTRY

Water quality criteria are presented in Table 4-1. The measured data are compared, where possible, to these criteria to assess the extent of the pollution concerns in this tributary.

Table 4-1. State and Federal water quality criteria available for parameters sampled at Church Creek

Parameter (mg/L, except as noted)	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
Total P	0.0225		USEPA 2000
BOD_5	7		USEPA 1986
Nitrate + Nitrite	0.095		USEPA 2000
TSS	500		USEPA 1974
TKN	None		
TPH	None		
*E. coli** (MPN/100ml)	235		COMAR 26.08.02.03-3.
Hardness	None		

* Used most restrictive standard for *E. coli* as a conservative approach: frequent full body contact recreation criterion.

Criteria are used to protect against both short-term and long-term effects. Numeric criteria are important where the cause of toxicity is known or for protection against pollutants with potential human health impacts or bioaccumulation potential. Narrative criteria can be the basis for limiting toxicity in discharges where a specific pollutant can be identified as contributing to the toxicity. Biological criteria can be used to complement traditional, chemical-specific criteria as indicators of aquatic health and impacts to the aquatic ecosystem.

Tables 4-2 and 4-3 compare baseflow and storm event results to the Federal and State acute and chronic criteria. Comparison and interpretation of Church Creek pollutant concentrations to Federal and State water quality criteria, and relating these conditions to ultimate ecological outcomes in the system, however, are difficult. Criteria do not exist for all

Table 4-2. Maximum concentrations observed for baseflow samples compared to appropriate criteria

Parameter (mg/L, except as noted)	Chronic	Acute	Church Creek	Parole Plaza
Lead (µg/L)	2.5	65	BDL	3*
Copper (µg/L)	9	13	8	25*
Zinc (µg/L)	120	120	91	180*
Total P	0.0225		0.12*	0.18*
BOD_5	7		4	10*
Nitrate + Nitrite	0.095		1.90*	6.70*
TSS	500		27	73
TKN	None		5.60	3.80
TPH	None		BDL	6.0
*E. coli*** (MPN/100ml)	235		644*	3,873*
Hardness	None		220	260

* Criterion exceeded
** Used most restrictive standard for *E. coli* as a conservative approach: frequent full body contact recreation criterion.
BDL: Below Detection Limit

Table 4-3. Maximum concentrations observed for wet weather samples compared to appropriate criteria

Parameter (mg/L, except as noted)	Acute	Church Creek	Parole Plaza
Lead (µg/L)	65	17	10
Copper (µg/L)	13	92*	68*
Zinc (µg/L)	120	170*	340*
Total P	0.0225	1.00*	0.42*
BOD_5	7	36*	57*
Nitrate + Nitrite	0.095	1.80*	6.00*
TSS	500	190	250
TKN	None	3.50	4.40
TPH	None	BDL	BDL
*E. coli*** (MPN/100ml)	235	29,090*	68,670*
Hardness	None	120	100

* Criterion exceeded
** Used most restrictive standard for *E. coli* as a conservative approach: frequent full body contact recreation criterion.
BDL: Below Detection Limit

parameters measured at the monitoring stations. In addition, a clear cause and effect relationship between water quality and ecological condition is difficult to determine. However, these comparisons can be used as general indicators of water quality impairment. Both State and Federal criteria are based on ambient stream conditions. Chronic criteria consider the maximum levels at which aquatic life can survive if continuously subjected to a pollutant concentration. Acute criteria reflect the maximum level at which an aquatic organism can survive if periodically subjected to a pollutant concentration. Since storm events represent a periodic condition, wet-weather samples are compared only to acute criteria.

As in prior years, comparisons to water quality criteria continue to indicate elevated pollutant concentrations in the Church Creek watershed, primarily during wet weather conditions. In particular, copper, zinc, total phosphorous, BOD_5, nitrate-nitrite, and *E. coli* frequently exceeded criteria at both sampling stations. Table 4-3 (above) shows the maximum concentrations for each sampling site, and compares these to the criteria. Additionally, as shown in Table 4-2, the Federal water quality criteria were exceeded for total phosphorous, nitrate-nitrite and *E. coli* during baseflow sampling at both the Church Creek and Parole Plaza Stations, with lead, copper, zinc and BOD_5 also being exceeded at the Parole Plaza station.

Table 4-4 shows the percentage of wet weather samples for which criteria were exceeded. Water quality criteria for the pollutants listed above were more frequently exceeded at the Parole Plaza monitoring station than at the Church Creek station for all contaminants except for BOD_5. Total phosphorous, nitrate-nitrite and *E. coli* concentrations remained high at both stations throughout the 2014 monitoring period, exceeding water quality criteria for at least 90% of the time at both Church Creek and Parole Plaza. Note that prior to site stabilization, total suspended solids concentrations had been particularly high due to construction activity at Annapolis Towne Centre. Following stabilization of the site in Fall 2008, the event mean concentrations for total suspended solids have dropped significantly. During the last three reporting years, no wet weather samples exceeded the water quality criterion for total suspended solids at either station.

Table 4-5 shows the annual average event mean concentrations that exceeded water quality criteria. As can be seen from the table, some criteria were consistently exceeded at both stations.

The high levels of pollutants observed in the watershed are typical for commercial and retail land uses that are coupled with high levels of automobile traffic and impervious surface area (USEPA, 1983). As shown in Table 2-2, 87% of the watershed to the Parole monitoring station and 69% of the watershed to the Church Creek Station is impervious.

In 2007, loading rates (Table 4-6 and 4-7) increased sharply at both stations. For 2008, loading rates were still high, when compared to historical values, but dropped dramatically from the 2007 levels. During the 2009 reporting year, loading rates dropped further, and aligned more closely with historical values. The high levels in 2007 likely resulted from the construction activity that was underway immediately upstream of the Parole Plaza Station. Since the majority of the site was stabilized by the end of 2008, this likely caused the pollutant loads to decrease.

Table 4-4. Percentage of all wet weather samples that exceed appropriate criteria

Parameter (mg/L, except as noted)	Criteria	Church Creek	Parole Plaza
Lead (µg/L)	65	0	0
Copper (µg/L)	13	33	86
Zinc (µg/L)	120	10	48
Total P	0.0225	95	100
BOD_5	7	24	19
Nitrate + Nitrite	0.095	90	100
TSS	500	0	0
TKN	None	NA	NA
TPH	None	NA	NA
*E. coli** (MPN/100ml)	235	95	100
Hardness	None	NA	NA

* Used most restrictive standard for *E. coli* as a conservative approach: frequent full body contact recreation criterion.

Table 4-5. Annual average event mean concentrations and criteria (parameters that exceeded appropriate criteria are indicated)

Parameter (mg/L, except as noted)	Chronic	Acute	Church Creek	Parole Plaza
Lead (µg/L)	2.5	65	4[a]	3[a]
Copper (µg/L)	9	13	11[a]	21[b]
Zinc (µg/L)	120	120	66	120
Total P	0.0225		0.138[a]	0.146[a]
BOD_5	7		3.53	4.33
Nitrate + Nitrite	0.095		0.332[a]	0.575[a]
TSS	500		39.71	48.77
TKN	None		0.590	0.772
TPH	None		2.5	2.5
*E. coli** (MPN/100ml)	235		8,638.07[a]	12,716.40[a]
Hardness	None		38.32	38.18

[a] Chronic or general criterion exceeded
[b] Acute criterion exceeded
* Used most restrictive standard for *E. coli* as a conservative approach: frequent full body contact recreation criterion.

Table 4-6. Total annual loading rates, in pounds, observed at the Parole Plaza Sampling Station from 2002 to 2014

Year	BOD	TSS	TP	TKN	NO_3+NO_2	Zinc	Lead	Copper	Hardness	Fecal Coliform[(a)]
2002	2,912	26,585	1,178	388	323	58	14	1	NA	1,152,001
2003	21,665	86,385	372	1,477	714	176	69	15	NA	5,350,164
2004	8.025	57,447	293	655	391	57	7	8	NA	402,127
2005	4,573	33,015	184	483	350	50	12	8	NA	665,232
2006	13,562	94,306	650	1,867	410	177	13	25	NA	3,360,952
										***E. coli*[(a)]**
2007	40,009	848,116	1,649	2,328	1,401	349	26	162	NA	11,017
2008[(b)]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2009	2,175	11,787	59	490	117	56	0.8	6.5	NA	2,115
2010	2,209	17,609	89	309	120	40	1.2	4.1	NA	1,740
2011	2,114	13,894	42	371	131	58	1.1	6.3	6,987	2,682
2012	3,660	15,335	62	284	214	57	1.0	6.6	14,578	10,209
2013	1,481	6,079	34	155	108	34	0.5	4.9	8,586	16,041
2014	2,040	18,953	54	536	497	50	1.0	8.1	36,945	12,716
Mean	**8,034**	**102,459**	**389**	**779**	**398**	**97**	**12**	**21**	**16,774**	**8,074[(c)]**

(a) Units of Fecal Coliform and *E. coli* are MPN/100 mL.
(b) In 2008, monitoring was conducted for both outfalls at Parole Plaza, but continuous level monitoring was not available for the 54" RCP; therefore, loads could not be calculated.
(c) Mean *E. coli* value, does not include pre-2007 Fecal Coliform data.

Table 4-7. Loading rates, in pounds, observed at the Church Creek Sampling Station from 2002 to 2014

Year	BOD	TSS	TP	TKN	NO_3+NO_2	Zinc	Lead	Copper	Hardness	Fecal Coliform*
2002	6,408	58,501	2,593	854	711	127	32	3	NA	2,534,970
2003	47,673	190,090	818	3,250	1,571	387	151	32	NA	11,773,001
2004	17,660	126,411	645	1,441	860	126	19	18	NA	884,887
2005	10,062	72,648	405	1,062	771	109	27	16	NA	1,463,839
2006	29,844	207,520	1,431	4,109	902	390	29	54	NA	7,395,753
										E. coli*
2007	265,499	3,312,794	8,381	20,330	436,206	3,663	277	652	NA	1,755
2008	60,843	458,185	3,037	12,468	4,444	693	37	36	NA	3,857
2009	35,521	206,184	1,296	9,377	2,505	531	30	57	NA	3,912
2010	49,256	341,877	2,066	9,561	2,912	739	39	77	NA	3,358
2011	42,883	214,820	1,340	7,410	3,606	704	30	41	259,076	3,995
2012	40,145	150,490	1,103	3,714	3,018	551	20	31	250,747	5,549
2013	43,980	180,946	899	3,326	2,782	558	27	57	314,179	2,399
2014	31,969	299,830	1,065	12,177	6,019	551	27	78	646,801	8,638
Mean	**52,442**	**447,715**	**1,929**	**6,852**	**35,870**	**702**	**57**	**89**	**367,701**	**4,183****

* Units of Fecal Coliform and *E. coli* are MPN/100 mL.
** Mean *E. coli* value, does not include pre-2007 Fecal Coliform data.

During the 2014 reporting year, loading rates increased for all sampled parameters at the Parole Plaza Station when compared to the 2013 reporting year except for *E. coli*. At the Church Creek Station, 2014 reporting year loading rates increased for all sampled parameters when compared to the 2013 reporting year except for BOD_5, zinc and lead. The sharp increase in *E. coli* loads at the Church Creek station may be due to an increase in pet waste washing into the storm drain system as a result of the likely increase in occupancy of the Annapolis Towne Centre residential buildings. This same increase was observed at the Parole Plaza station during the 2013 reporting year, but a slight decrease in *E. coli* loads occurred at this station in 2014.

From 2009 to 2014, the loading rates at Parole Plaza have tended to be below the levels existing prior to the redevelopment of the Towne Centre. However, at the Church Creek Station, most of the sampled parameters have exceeded average pre-construction (2002-2006) monitoring levels, and continued doing so in 2014.

Seasonal pollutant loads in 2014 are provided in Table 4-8. Hardness was much higher in the winter at both stations due to the large amount of road salt used to deice local roads during a winter that produced an abnormally large amount of snow and ice. TKN and nitrate-nitrite loads were also highest in the winter months at each station. Water chemistry monitoring during the 2014 winter months consisted solely of baseflow sampling, and the higher natural background nitrogen concentrations observed during baseflow (which are often diluted during storm events) is the likely cause of the elevated winter TKN and nitrate-nitrite loads. All other Church Creek pollutant loads, except *E. coli*, were highest in the spring. The increase in metal and total phosphorus loads were likely associated with the increase in TSS, which is likely a product of accelerated stream bank erosion occurring after several freeze-thaw cycles facilitated by the consistent swings in temperature observed during the 2014 winter. All metal, total phosphorus, and TSS loads were highest in the fall at the Parole Plaza station, which is primarily due to the total volume of water passing through this station in the fall being much higher than volumes observed in the other seasons. It should be noted, however, that the limited number of samples collected for each season ultimately makes it difficult to draw strong conclusions about seasonal pollutant loading rates. These interpretations should be viewed cautiously.

Table 4-8. Seasonal loading rates, in pounds, observed at the Church Creek and Parole Plaza sampling stations in 2014

Season	BOD	TSS	TP	TKN	NO_3+NO_2	Zinc	Lead	Copper	Hardness	*E. coli**
Church Creek										
Summer	4,862	64,729	205	377	165	103	6.1	17.6	52,171	12,577
Fall	5,425	73,315	276	1,371	777	133	6.5	21.8	77,841	5,712
Winter	5,090	42,986	177	7,830	3,497	136	2.1	9.8	394,902	403
Spring	16,593	118,800	407	2,598	1,579	179	11.8	29.0	121,887	9,859
Parole Plaza										
Summer	277	2,783	11	55	41	7	0.2	1.4	1,815	14,474
Fall	502	8,375	18	91	63	18	0.4	2.9	6,499	11,363
Winter	815	5,954	17	332	344	17	0.2	2.4	25,822	576
Spring	447	1,841	8	59	48	8	0.1	1.4	2,810	11,927

* Units of *E. coli* are MPN/100 mL.

Annual average event mean concentrations were plotted for each monitoring year. Plots were constructed to illustrate the impact that construction activity and redevelopment of the Annapolis Towne Centre site has had on water quality within the study reach. Figures 4-1 through 4-5 show how the event mean concentrations have changed from 2004 to 2014 at the Parole Monitoring Station. As can be seen from the graphs, nearly every concentration rose substantially between 2006 and 2007 when the majority of the site work was being conducted at the Towne Centre. These concentrations fell significantly in 2008, as the site was stabilized, and continued the downward trend in 2009. The reduction in pollutant concentrations stabilized in 2010 and 2011 possibly indicating that the stream has reached a post-construction baseline. Pollutant concentrations in 2014 increased when compared to those from 2013, with the exception of a drop in *E. coli*, and no change in TPH. The 2013 rise in TPH was due to an increase in the detection limit, and may not be associated with an actual increase in concentration as greater than 95% of TPH concentrations fell below the detection limit. It is important to note that the 2013 data included in these plots do not include summer season data, which is often the season that produces the highest event mean concentrations for many of the parameters.

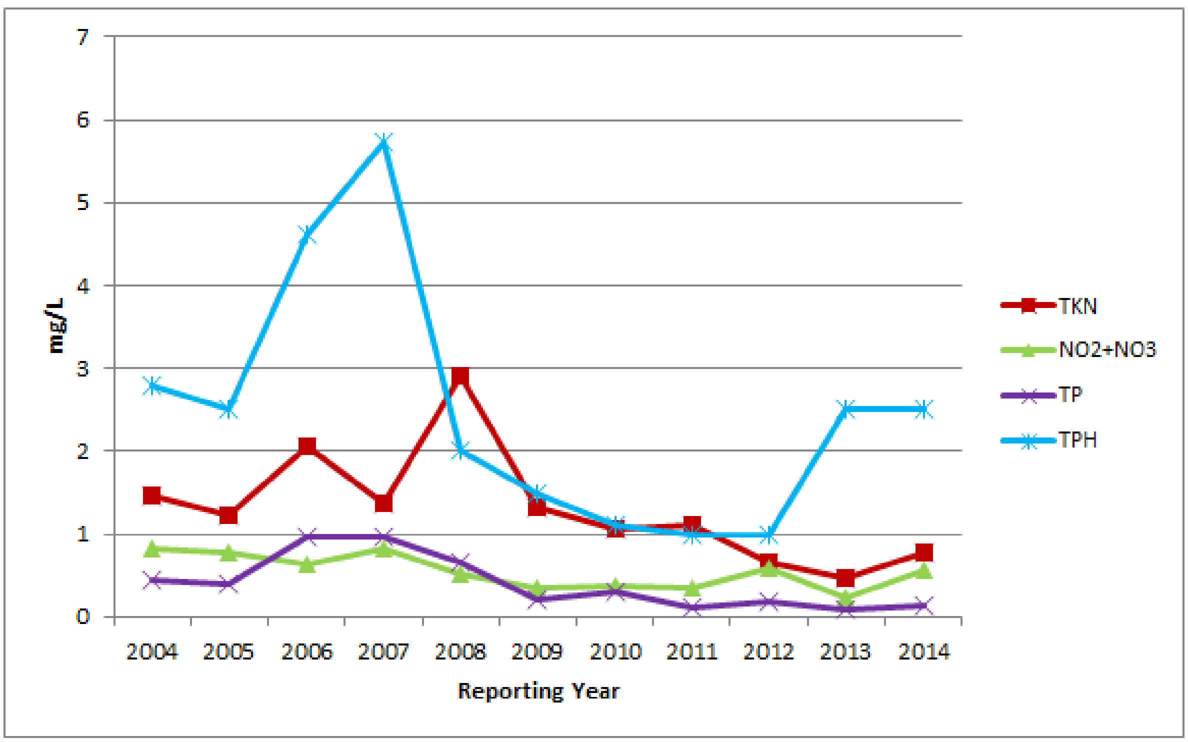

Figure 4-1. Parole station long-term monitoring: annual EMCs (TKN, NO_2+NO_3, TP, TPH; mg/L)

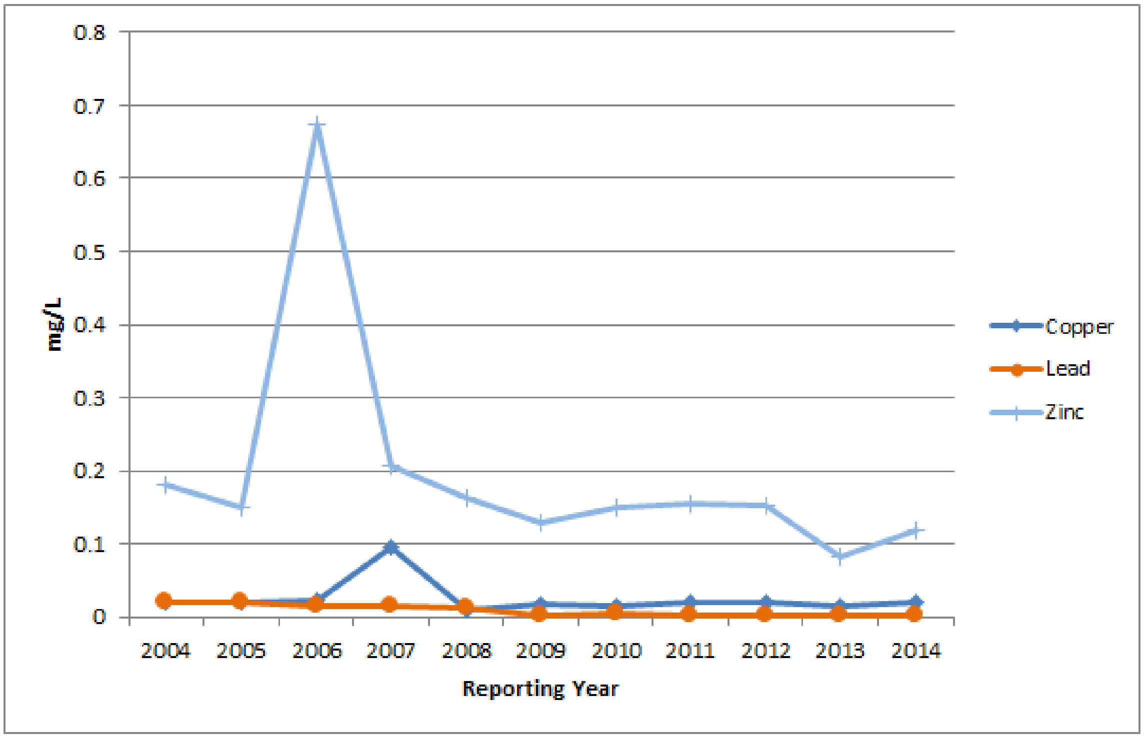

Figure 4-2. Parole station long-term monitoring: annual EMCs (Cu, Pb, Zn; mg/L)

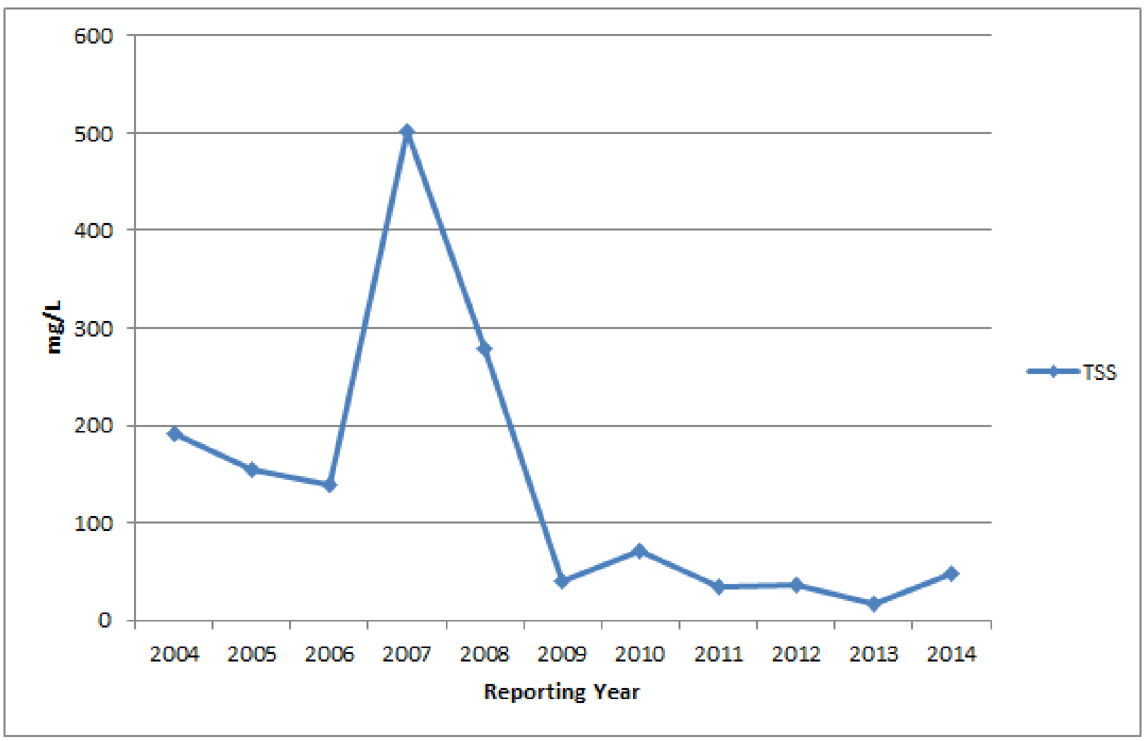

Figure 4-3. Parole station long-term monitoring: annual EMCs (TSS; mg/L)

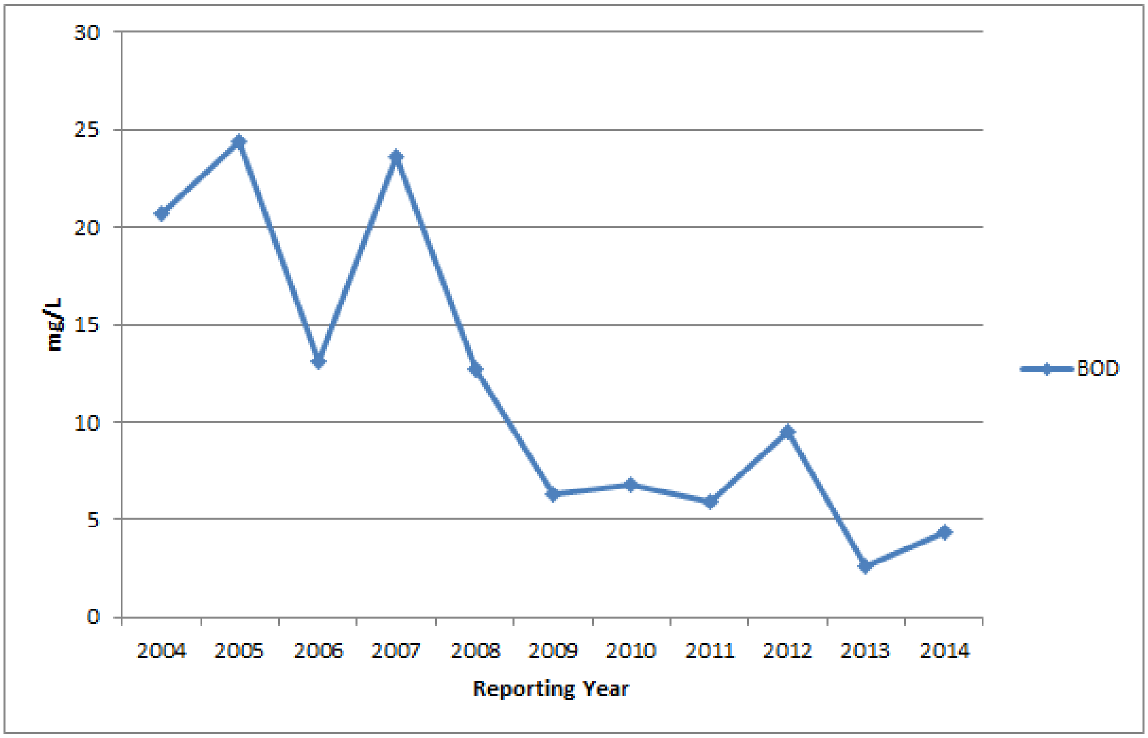

Figure 4-4. Parole station long-term monitoring: annual EMCs (BOD_5; mg/L)

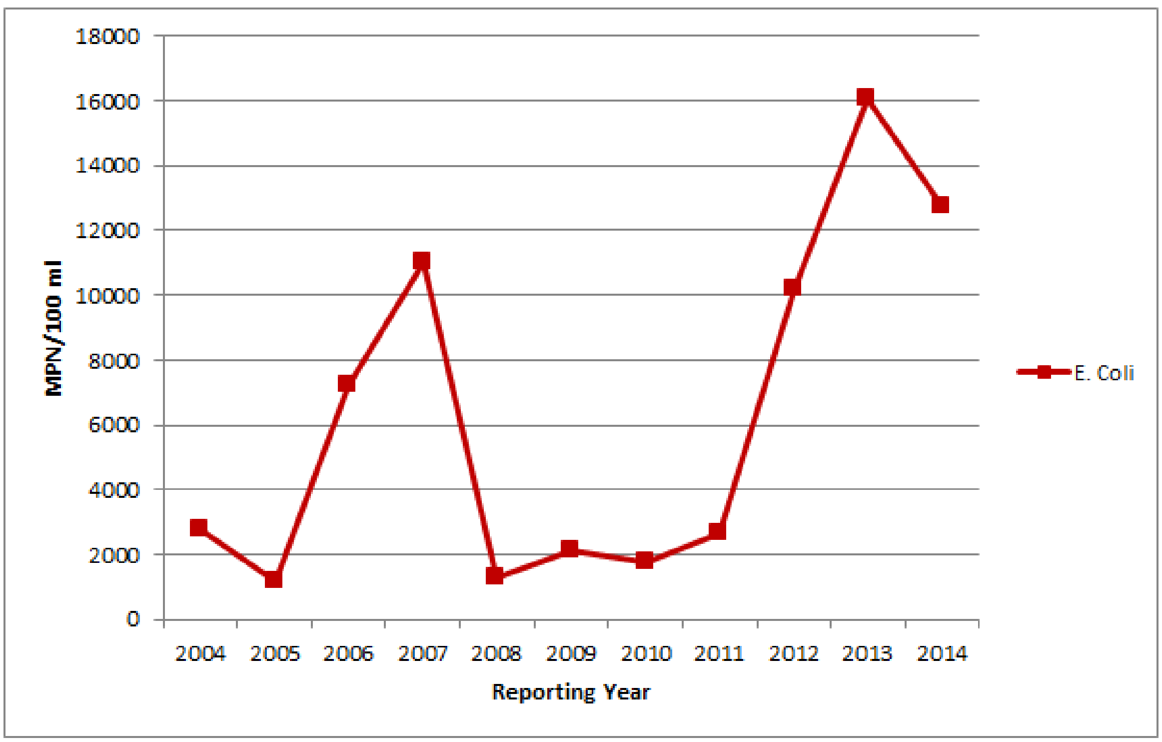

Figure 4-5. Parole station long-term monitoring: annual EMCs (*E. coli*; MPN/100 mL)

Figures 4-6 through 4-10 show similar trends in EMCs for the Church Creek Monitoring Station. Pollutant concentrations at Church Creek increased in 2014 for all monitored parameters, with the exception of TPH, which showed no change from 2013. Note that the apparent rise in TPH at Church Creek in 2013, like Parole Plaza, was due to an increase in the detection limit. Also like Parole Plaza, summer season concentrations were not included with the 2013 EMC data.

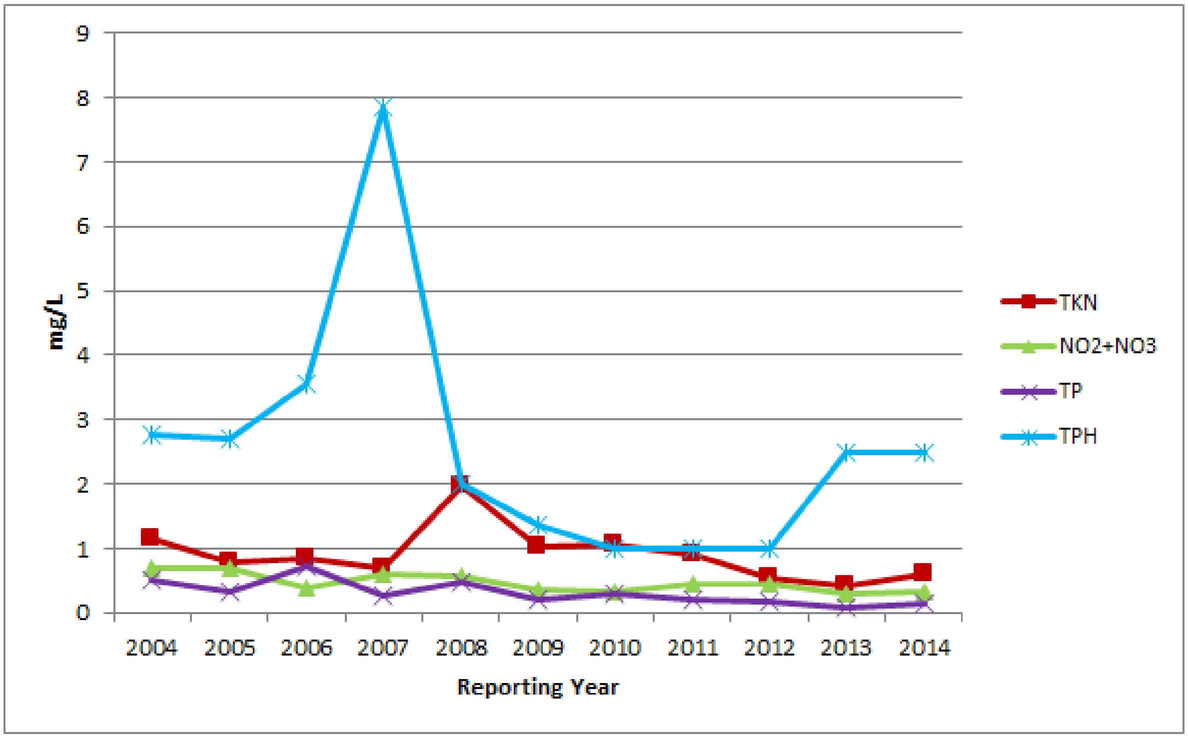

Figure 4-6. Church Creek station long-term monitoring: annual EMCs (TKN, NO_2+NO_3, TP, TPH; mg/L)

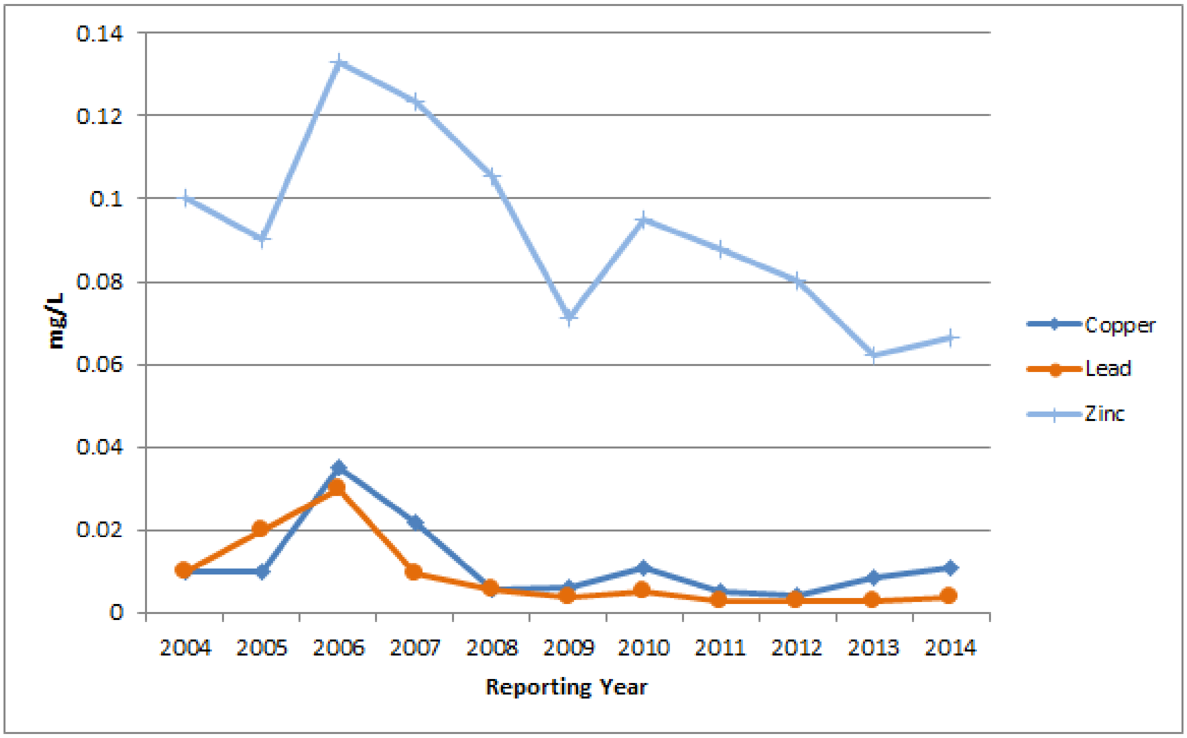

Figure 4-7. Church Creek station long-term monitoring: annual EMCs (Cu, Pb, Zn; mg/L)

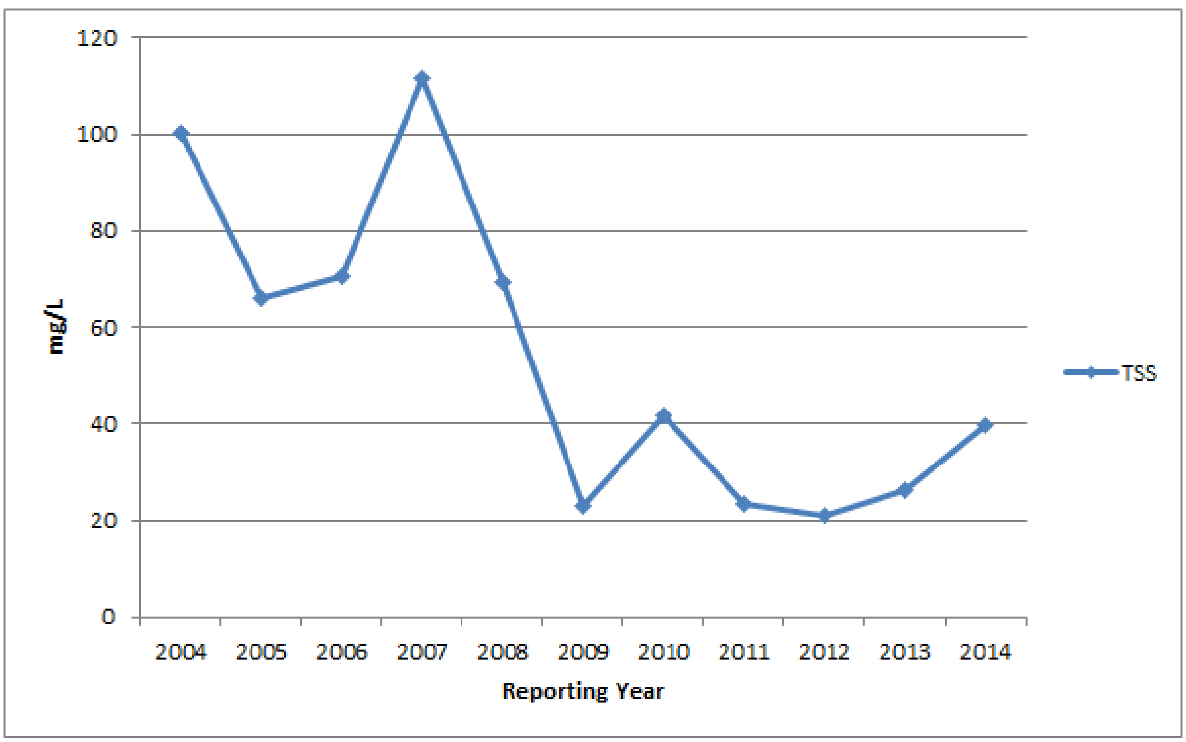

Figure 4-8. Church Creek station long-term monitoring: annual EMCs (TSS; mg/L)

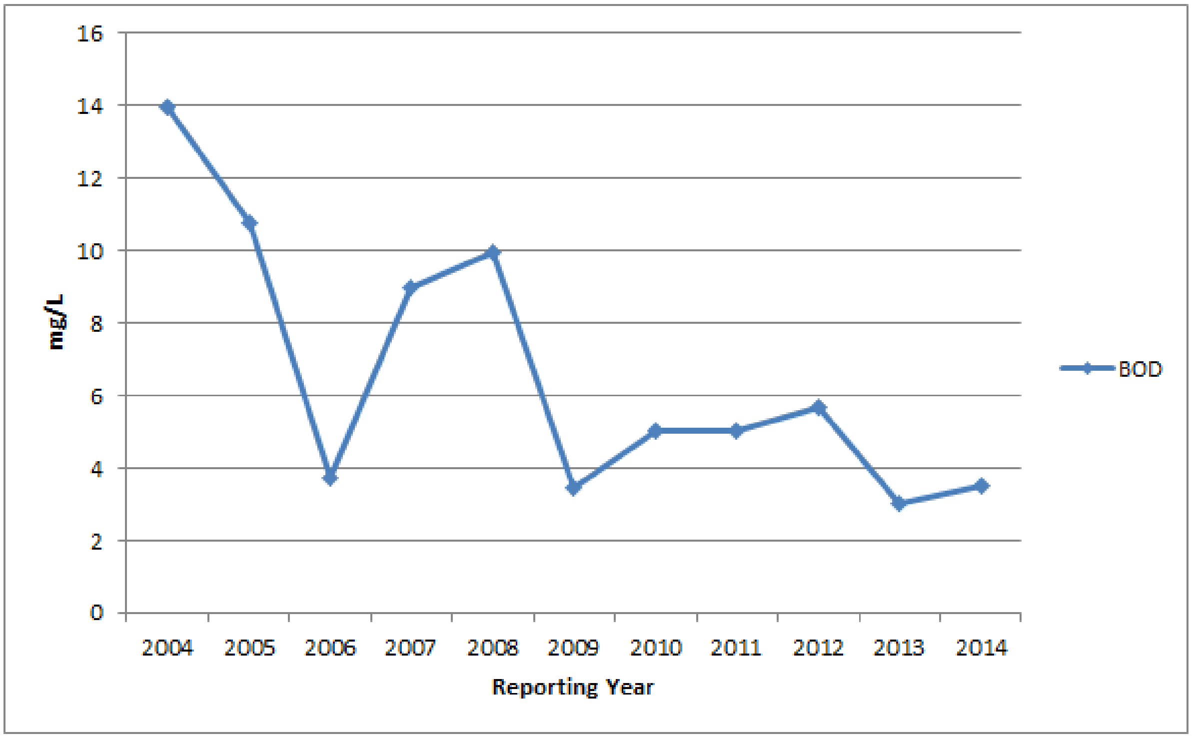

Figure 4-9. Church Creek station long-term monitoring: annual EMCs (BOD_5; mg/L)

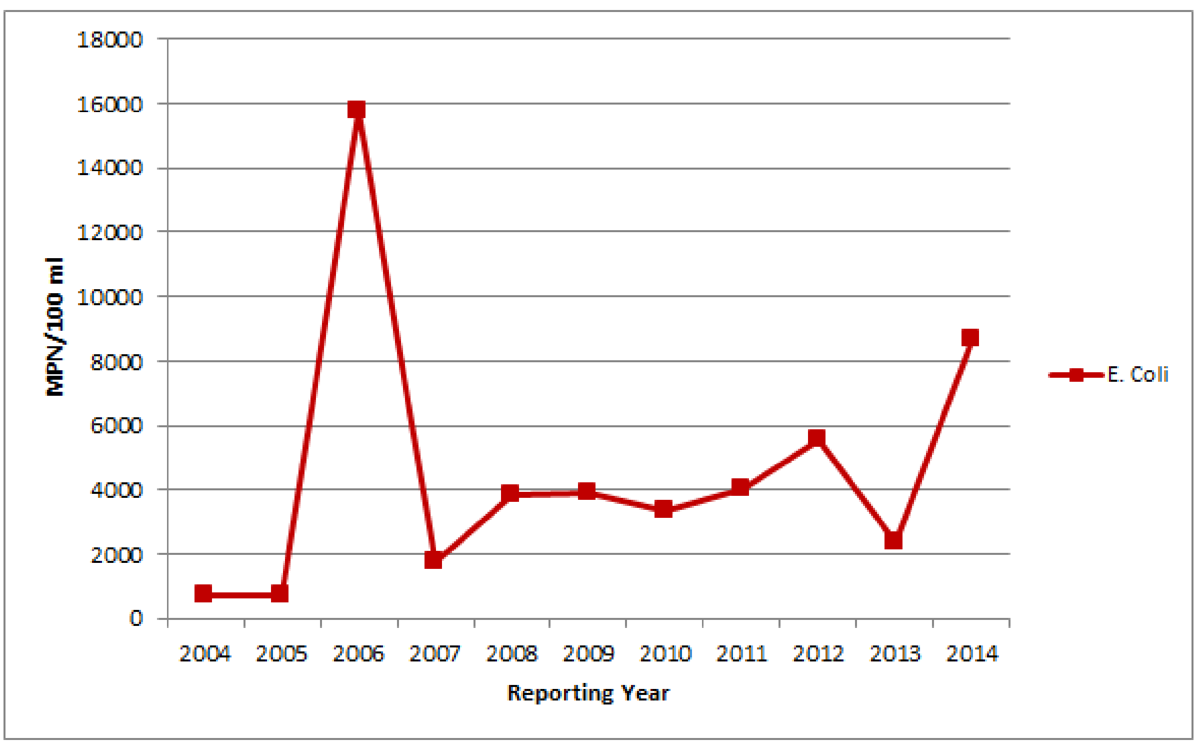

Figure 4-10. Church Creek station long-term monitoring: annual EMCs (*E. coli*; MPN/ 100 mL)

4.2 PHYSICAL HABITAT AND BIOLOGICAL CONDITIONS

Physical habitat and biological conditions within the Church Creek study area continue to be impaired by urbanization within the surrounding watershed. Stream physical habitat remains degraded throughout the entire study reach and appears to have changed very little from the previous year (Table 4-9, Figure 4-11). All four sites were rated the same in 2014 as in 2013 indicating no change in habitat condition. Urban stressors such as hydrologic alteration (i.e., increased runoff, increased frequency of peak flows, reduced infiltration) within the watershed have resulted in a reduction of stable instream habitat as well as increased channel erosion and sedimentation. A general lack of a stable epifaunal substrate further limits the capacity of the stream to support a diverse and healthy macroinvertebrate community. In addition, elevated conductivity levels reflect high levels of dissolved solids during baseflow conditions, which typically indicate the presence of water quality stressors.

Table 4-9. PHI scores from 2006 to 2014

Site		CC-01	CC-02	CC-03	CC-04
2006	PHI Score	51.1	55.4	56.8	No Data
	Rating	Degraded	Degraded	Degraded	Collected
2007	PHI Score	61.2	59.1	65.7	60.8
	Rating	Degraded	Degraded	Degraded	Degraded
2008	PHI Score	57.1	56.8	66.6	62.6
	Rating	Degraded	Degraded	Partially Degraded	Degraded
2009	PHI Score	73.2	59.6	69.2	65.2
	Rating	Partially Degraded	Degraded	Partially Degraded	Degraded
2010	PHI Score	64.3	53.9	65.0	62.3
	Rating	Degraded	Degraded	Degraded	Degraded
2011	PHI Score	67.4	55.3	66.9	61.5
	Rating	Partially Degraded	Degraded	Partially Degraded	Degraded
2012	PHI Score	69.2	51.5	62.5	58.3
	Rating	Partially Degraded	Degraded	Degraded	Degraded
2013	PHI Score	63.0	53.5	66.6	57.5
	Rating	Degraded	Degraded	Partially Degraded	Degraded
2014	PHI Score	65.85	56.16	70.79	61.01
	Rating	Degraded	Degraded	Partially Degraded	Degraded

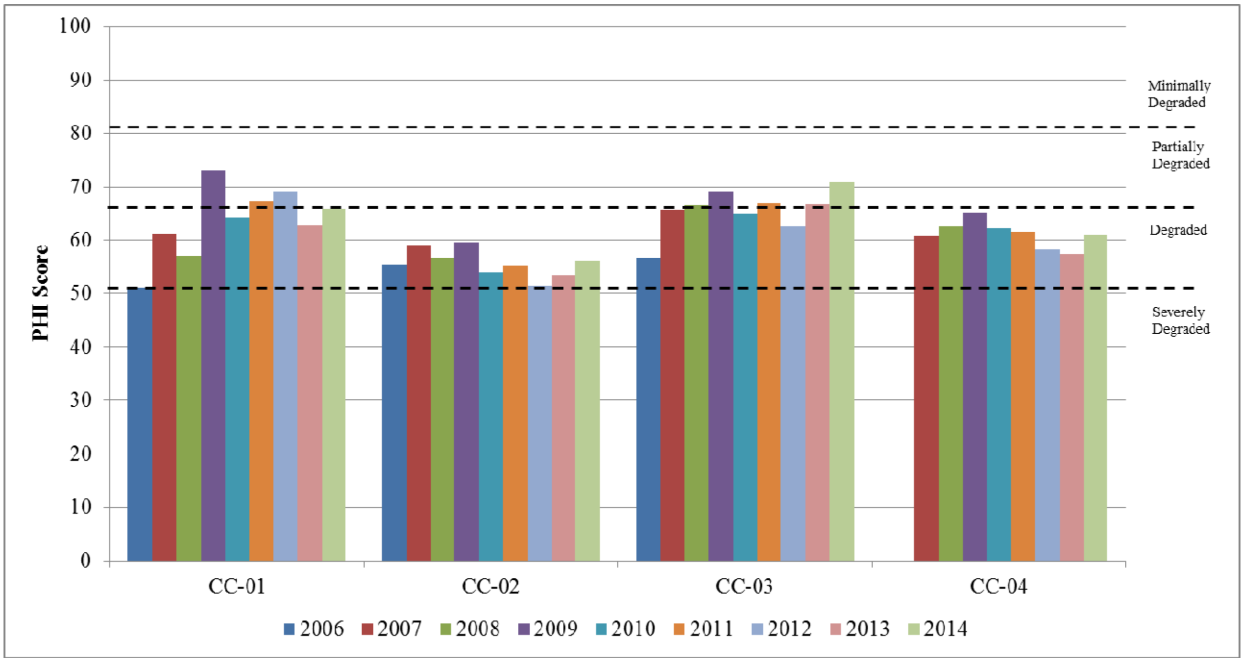

Figure 4-11. Comparison of PHI scores from 2006 to 2014

In 2013 and 2014, the updated MBSS PHI methods (Paul et al. 2003) were used to calculate PHI instead of the original MBSS methods (Hall et al. 2002) which had been used in the Church Creek watershed reports from prior years. Scores for 2006-2012 shown in Table 4-9 and Figure 4-11 were calculated using the original method, while scores for 2013 and 2014 were calculated using the updated method.

Biological impairment is evident within this watershed as reflected by the macroinvertebrate communities found throughout the study reach. A comparison of BIBI scores from 2006 through 2014 (Table 4-10) shows no substantial change in biological conditions throughout the study reach. While BIBI scores tend to fluctuate from year to year, overall classifications have changed very little with sites consistently rating either "Poor" or "Very Poor", no clear trends have been established (Figure 4-12). It appears that the biological community continues to be limited by the presence of urban stressors and the degraded physical condition of the stream, and annual shifts in BIBI scores are likely related to random and systematic variability inherent in the assessment process.

Table 4-10. BIBI scores from 2006 to 2014

Site		CC-01	CC-02	CC-03	CC-04
2006	BIBI Score	1.86	2.43	1.86	No Data
	Rating	Very Poor	Poor	Very Poor	Collected
2007	BIBI Score	1.00	1.86	2.71	2.71
	Rating	Very Poor	Very Poor	Poor	Poor
2008	BIBI Score	2.43	2.43	2.43	2.14
	Rating	Poor	Poor	Poor	Poor
2009	BIBI Score	1.86	1.86	2.14	2.43
	Rating	Very Poor	Very Poor	Poor	Poor
2010	BIBI Score	1.29	1.86	1.57	2.14
	Rating	Very Poor	Very Poor	Very Poor	Poor
2011	BIBI Score	1.57	1.86	1.57	2.14
	Rating	Very Poor	Very Poor	Very Poor	Poor
2012	BIBI Score	1.86	2.43	1.57	2.43
	Rating	Very Poor	Poor	Very Poor	Poor
2013	BIBI Score	1.57	2.43	1.86	1.29
	Rating	Very Poor	Poor	Very Poor	Very Poor
2014	BIBI Score	1.57	1.86	1.29	1.57
	Rating	Very Poor	Very Poor	Very Poor	Very Poor

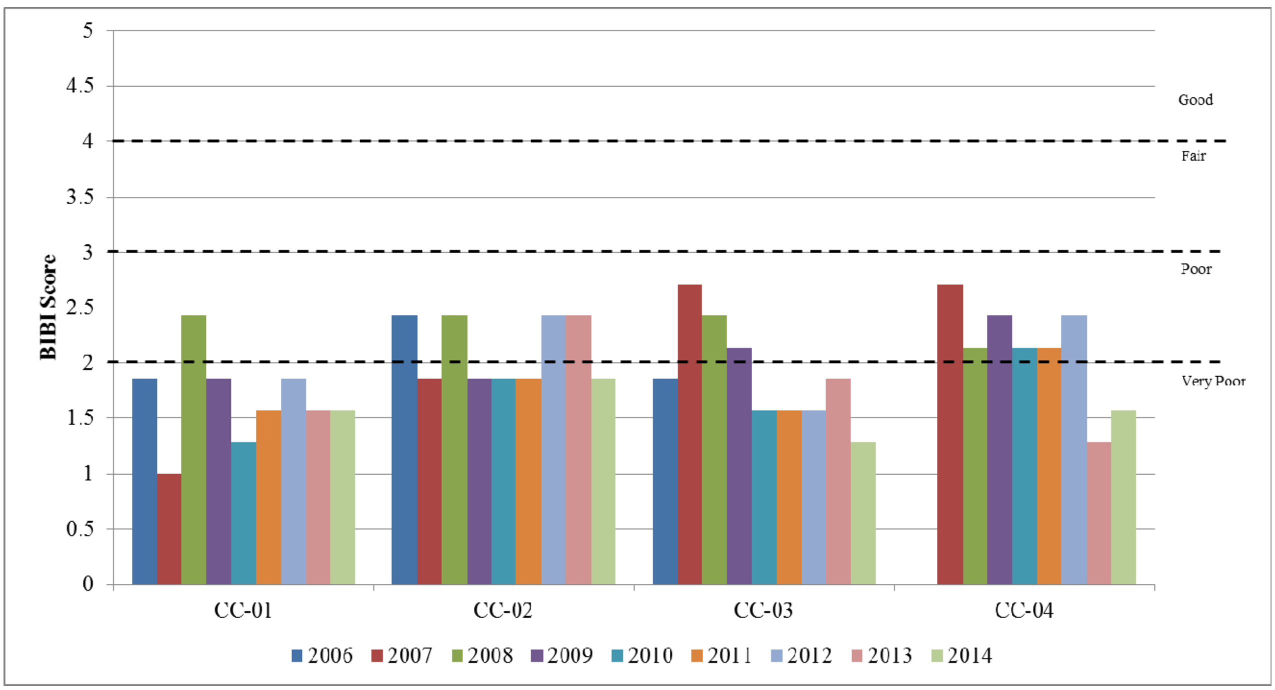

Figure 4-12. Comparison of BIBI scores from 2006 to 2014

4.3 GEOMORPHIC CONDITIONS

The Church Creek study area has a very high percentage of impervious surface cover (approximately 64 percent), and only one reach was classified as a C channel, which are generally considered stable stream types due to adequate floodplain connectivity. In contrast, the other four reaches were classified as either F or G channels, which are more entrenched and less stable. The Parole Plaza Tributary maintains some limited connectivity to its floodplain even though there are significant stormwater inputs feeding into the stream, which typically results in accelerated channel erosion and degradation. Evolution of channel type over the course of the study at each cross section is presented in Table 4-11. It is likely that current stormwater management and wetland storage on the Church Creek mainstem, as well as the presence of an intact riparian vegetative buffer along much of the stream corridor, contributes to minimizing some of the adverse effects of the high imperviousness in the watershed. Additionally, grade controls such as the culvert at Solomon's Island Road and cobble rip-rap armoring at XS-5 likely prevent degradation from occurring in the channel upstream. Nonetheless, there are clear indications of channel instability (i.e., degradation, aggradation, widening) in the upper reaches of the Parole Plaza Tributary, and thus, a need for additional stormwater management to prevent further channel erosion.

Table 4-11. Past Rosgen classifications

Cross Section	2006	2007	2008	2009	2010	2011	2012	2013	2014
XS-1	E5	C5	E4	E5 → C5	E5 → C4/5	C4/5 → F4/5	F5	F4	F5/4
XS-2	E5	E5	E5	E5	E5	G5c	G5c	G5c	G4c
XS-3	G5c	G5c	G5c	G5c	G5c	No Data	No Data	G4c	G4c
XS-4	E5	E5	E5	E5	E5	E5	E5	C5	C5
XS-5	E5b	C5	C5	C5	C3/5	C3/5	C3/5	F4/3	F3

Bankfull channel dimensions (cross sectional area, width, depth) in the Church Creek study area showed significant departure from expected values, as derived from Maryland Coastal Plain regional relationships of bankfull channel geometry (McCandless, 2003). Almost all dimensions were generally larger in the Church Creek study area (see Figures 4-13, 4-14, and 4-15), and were often more similar to relationships of bankfull channel geometry derived from gaged urban watersheds located in the Coastal Plain. These relationships were developed for an urban stream restoration project in Anne Arundel County (AADPW 2002). Values measured in 2014 were roughly consistent with prior assessment results. This reflects the higher level of imperviousness in the study area, as compared to the lower impervious levels in the drainage areas used to develop the regional relationship data. The results suggest that this stream has become enlarged as a result of the high imperviousness, and is both wider and deeper than stable C and E type channels located in rural/suburban watersheds of the coastal plain. It should be noted, however, that locating bankfull elevations in the field on actively eroding, previously stabilized, or incising channels is difficult and not recommended due to unreliable and/or misleading indicators, and instead bankfull elevations should be estimated using the aforementioned regional curves (Rosgen, personal communication, May 2011). Where bankfull indicators were suspect or questionable, the indicator approximating the rural/ suburban regional curve for bankfull area was used to estimate bankfull elevations. Additionally, the Rosgen method is best used on streams that are free to adjust their lateral boundaries under the current discharge regime experienced by the system (Rosgen 1996). Given the high levels of rip rap and/or concrete rubble armoring found in the reaches containing cross sections 2, 3 and 5, the accurate determination of the bankfull indicators in the field at these locations is problematic.

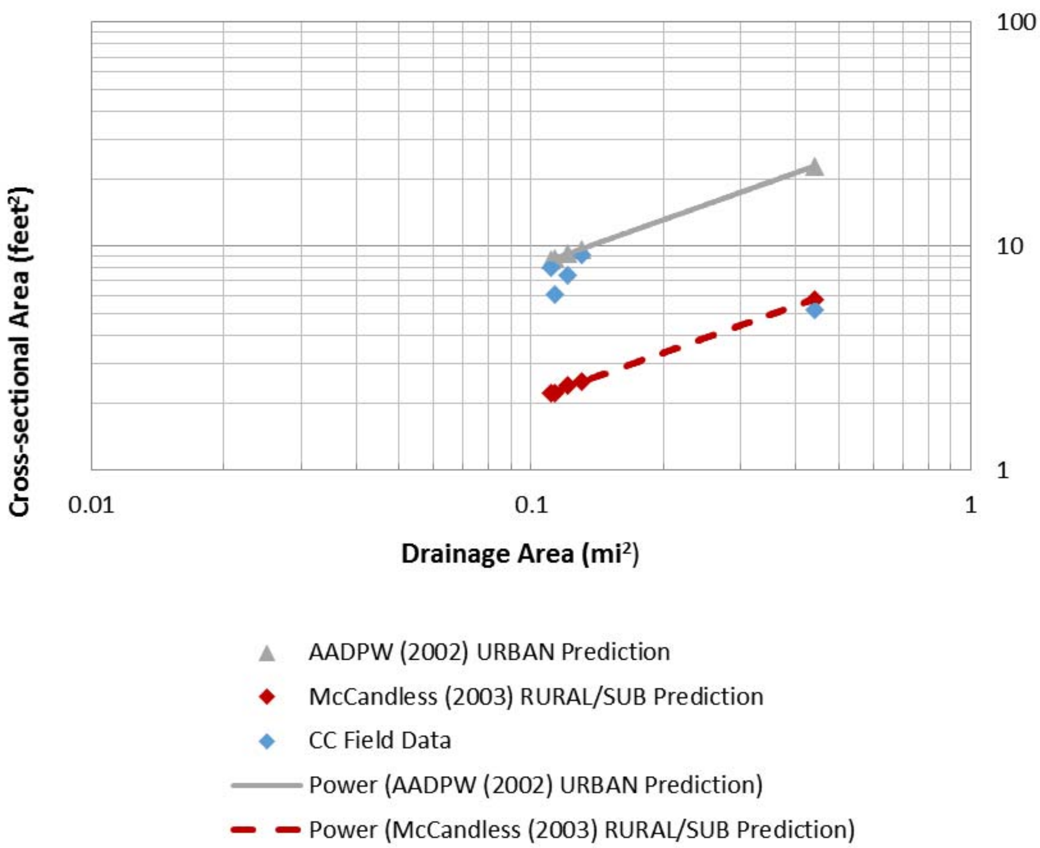

Figure 4-13. Comparison of bankfull channel cross sectional area to drainage area (CC = Church Creek, 2014 data)

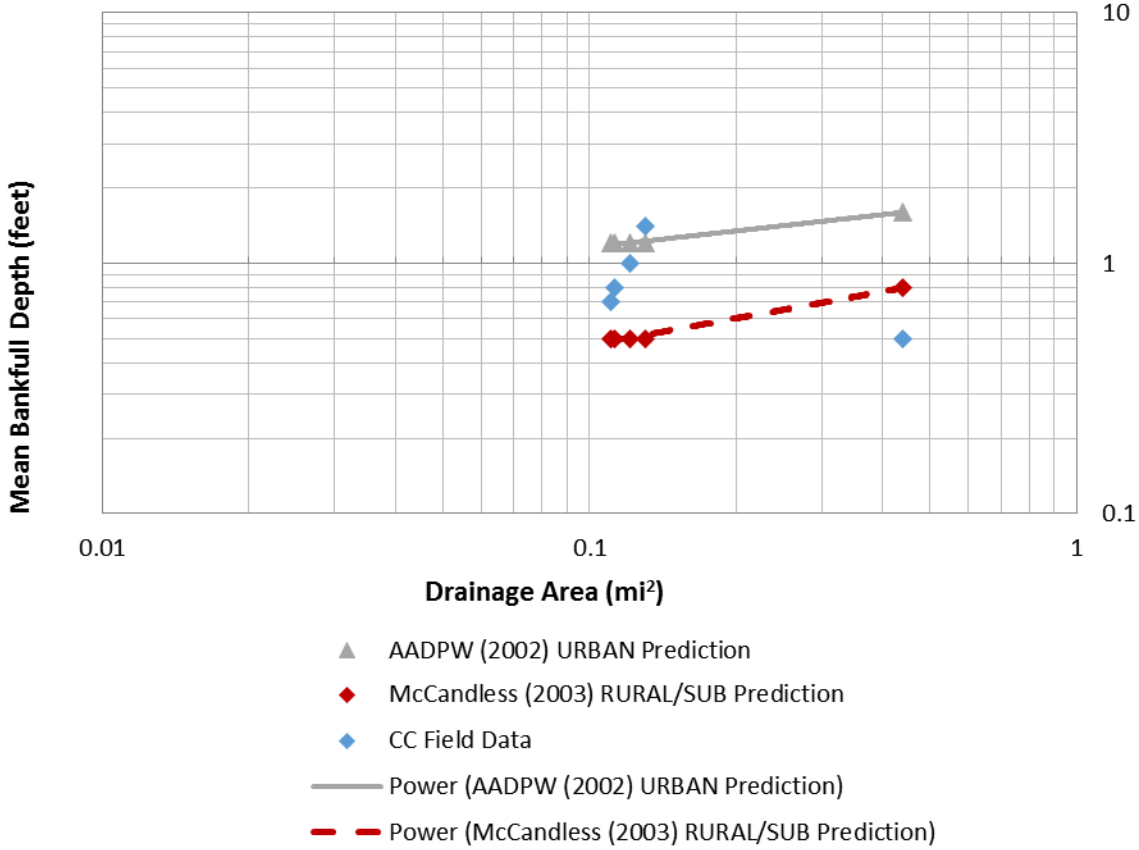

Figure 4-14. Comparison of mean bankfull depth to drainage area (CC = Church Creek, 2014 data)

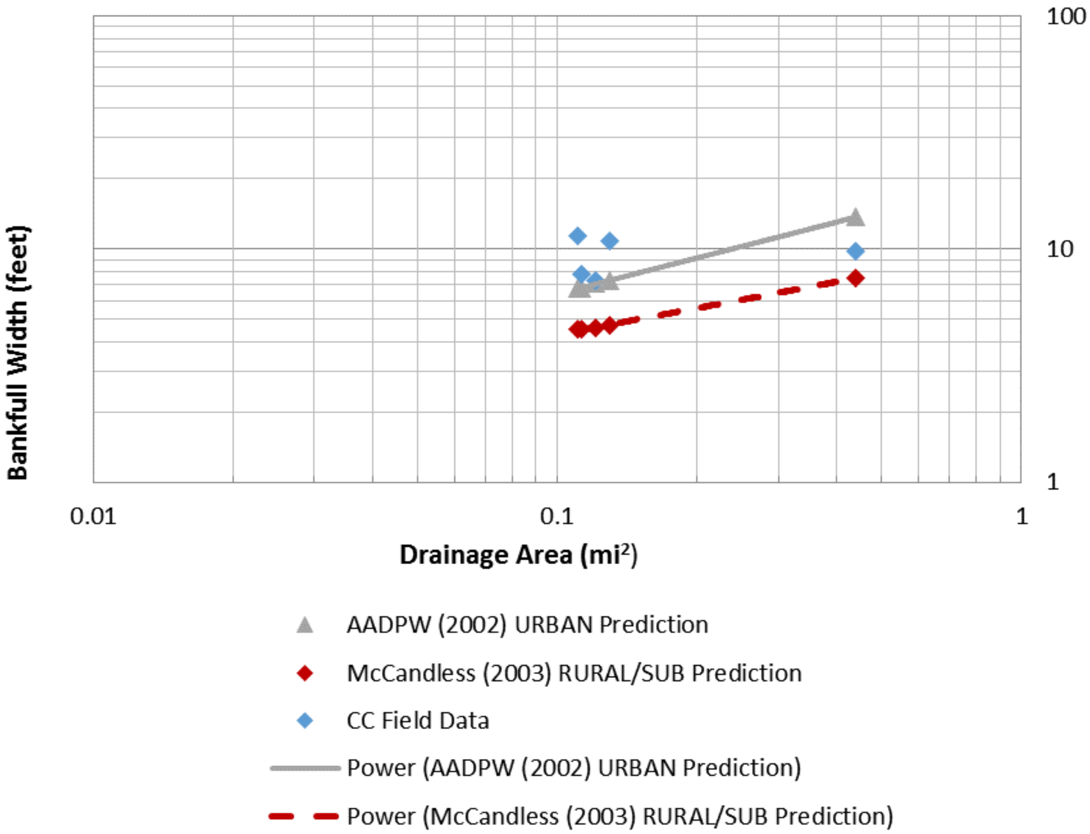

Figure 4-15. Comparison of bankfull width to drainage area (CC = Church Creek, 2014 data)

Three of the five cross sections showed enlargement from channel erosion while the other two showed aggradation as compared to baseline measurements (Table 4-12). Due to the replacement of XS-3 following channel restoration, data were compared to 2007 at this location only, whereas all other comparisons were made to 2003 data. Cross sectional area from 2011 through 2014 was calculated using the top of bank elevation from the baseline survey in order to standardize comparisons and reduce variability among more subjective bankfull elevation reference points, or even changes that can occur to top of bank elevation from year to year. It is important to note that calculations prior to 2011 did not use the baseline reference elevation, instead they used the corresponding year's top of bank elevation for calculating cross sectional area, and consequently these values are not directly comparable to the cross sectional areas reported in 2011 through 2014. Comparison of baseline cross sectional area is however comparable to 2011 through 2014 since all calculations are made using the same top of bank elevation.

Table 4-12. Summary of cross sectional area changes over time.

Cross Section[(a)]	XS-1	XS-2	XS-3	XS-4	XS-5
July 2003	16.8	8.9	ND	14.3	9.7
Jan 2005	20.7	10.0	ND	14.4	9.9
March 2006	19.4	8.0	ND	18.4	9.5
March 2007	19.4	8.9	19.8	17.4	9.0
May 2008	20.1	10.1	16.7	18.0	8.9
July 2009	19.6	9.8	21.0	15.4	8.3
May 2010	19.8	10.3	20.4	16.4	8.5
July 2011[(b)]	21.3	15.9	20.6	7.8	10.5
April 2012[(b)]	21.6	15.4	19.2	11.7	5.9
July 2013[(b)]	21.0	15.5	20.2	11.7	6.9
June 2014 [(b)]	22.4	16.2	20.6	6.8	6.7
% Change 2003-2014	33.3	82	4.0[(c)]	-52.4	-30.9
% Change 2011-2014	5.2	1.9	0	-12.8	-36.2

[(a)] All values listed here are for top of bank area and are listed in square feet
[(b)] Values obtained using reference elevations (top of bank) from baseline measurements
[(c)] % change from 2007
ND = No Data

Using the current reference elevation comparison method, the upstream cross sections (XS-1 and XS-2) showed fairly substantial enlargement, with increases of approximately 33.3%, and 82% respectively, since baseline measurements began in 2003. The bed elevation at XS-1 appears to have dropped more than half a foot since 2003, remaining relatively stable since last year, but with a noticeable amount of bed scour occurring between 2008 and 2009 (Appendix F). With the exception of minor scouring near the left bank, there has been very little overall change in bed elevation between the last two years of monitoring, 2013 to 2014. The channel at XS-2 has widened notably since 2003, with considerable erosion along the right bank and toe of slope on the right bank, although the left bank has not experienced further erosion during the last four years (Appendix F). Although cross section area comparisons between baseline and 2014 show a substantial increase, percent change occurring over the last four years only has been fairly minimal with 5.2% increase at XS-1 and 1.9% increase at XS-2.

Cross section XS-3 has had very minimal changes in cross-sectional area with just a 4% increase since 2003 baseline measurements and 0% change between 2011 and 2014. Between 2009 and 2011, the XS-3 channel appeared to be enlarging, as the right bank and bottom of the right bank experienced some erosion and the cross-sectional area increased (Appendix F). However, during the past three years, the right bank has experienced some aggradation, while the stream bed has downcut slightly (Appendix F). Between 2012 and 2014 monitoring, there has been little change with the exception of slight widening and scouring along the right bank. Cross section XS-3 continues to have yard waste (i.e., grass clippings, leaves, and branches) dumped along the left bank floodplain.

Conversely, the two most downstream cross sections (XS-4, and XS-5) showed varying degrees of aggradation, decreasing from baseline measurements in cross-sectional area 52.4%, and 30.9%, respectively. Between 2010 and 2011 cross section XS-4 had shown moderate signs of aggradation. Within the next year, the channel experienced erosion of the bed particularly along the right hand side of the stream. In the 2013 survey, signs of aggradation were again present and the stream bed characteristics resemble those of the 2011 survey. In 2014 the stream bed remained elevated as in 2011 and 2013 however there was slight widening along the right bank. A significant change at XS-4 first occurred between 2003 and 2006, where the average bed elevation dropped by more than one-half foot (Appendix F). The woody debris jam just downstream of XS-4 which formed between 2011 and 2012 is still present and contributing to debris and sediment accumulation in the channel and on the banks. Between 2011 and 2014 the cross-sectional area has decreased by 12.8% and the overall trend at this location is aggradation (a net 52% decrease in cross-sectional area compared to the baseline study). Cross section XS-5 has been armored with cobble-sized rip rap in its bed to protect the sewer line. Between 2012 and 2013, XS-5 appears to have eroded by several inches of sediment most notably near the left bank. During the past year however, there has been little change in both stream bed elevation and bank stability (Appendix F).

Based upon the data collected in 2014, biological and physical conditions within the Church Creek study area have not improved and remain in a degraded and impaired condition. Although the stream channel has been stabilized along several reaches, the effects on biota are yet to be seen from such efforts.

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APPENDIX A

STORM EVENT HYDROGRAPHS, NARRATIVES AND COMPOSITE SAMPLING METHOD TECHNICAL MEMORANDUM

TECHNICAL MEMORANDUM

TO: Janis Markusic, AACO DPW

FROM: James Tomlinson

DATE: 5/12/08

SUBJECT: Proposed Modifications to Sampling Procedures
Church Creek/Parole Plaza NPDES Monitoring 2008
KCI Job Order No. 01-032333.38

Dear Ms. Markusic,

Monitoring at the Parole Plaza station has historically entailed collecting storm water samples from a 60" corrugated metal pipe (CMP) outfall draining the Parole Plaza site. The rising, peak, and falling limb of each storm event was sampled and analyzed in the lab. In the summer of 2007, a newly-installed 54" reinforced concrete pipe (RCP) was connected to the Church Creek drainage network (refer to Figure 1). The new 54" RCP drains the *Annapolis Towne Center at Parole* construction site and contains portions of the drainage that had historically been passing through the 60" CMP. Based on plan reviews, on-site discussions with County staff /inspectors, and discussions with Mr. Matthew Kelly of Greenhorne & O'Mara Inc. (Head Engineer) it was determined that runoff from the *Annapolis Towne Centre at Parole* site would be discharging from both the 60" CMP and 54" RCP outfalls under post-construction conditions.

In order to maintain consistency in the characterization of the watershed, samples are being collected from both pipes. As in the 2006-2007 reporting year, the 2007-2008 reporting year has also encountered the challenge of determining the active drainage configuration during each sampled event. To address this problem, samples were collected for each limb of an event and taken to the laboratory for each pipe separately. In 2007, storm samples were collected and analyzed for both outfall pipes for three storm events (9/11/07, 10/9/07, and 10/19/07) at the Parole Plaza station. In 2008, storm samples were collected and analyzed for both outfall pipes for two storm events (1/10/08 and 1/17/08) at the Parole Plaza station.

Stage/discharge relationships were developed for both pipes, to determine the discharge from each pipe based on field-measured depths. The rating tables were used to determine discharges and total flow volumes for each limb of the storm. The reported concentrations for each limb were then weighted by the flow for that limb of the storm to determine the event mean concentration for each pipe. The event mean concentrations for each pipe were then flow weighted again for the total discharge through each pipe to determine the total event mean concentration for the *Annapolis Towne Center at* Parole site.

In March 2008, the sampling methodology was modified such that only one flow-weighted composite sample per event limb is collected and analyzed at the lab. The goal of compositing the discharge from both pipes is to ensure a comprehensive analysis of the storm water leaving the *Annapolis Towne Center at Parole* site during and after construction. The flow-weighted composite sample for each limb of an event is determined by the combined discharge of the 60" CMP and 54"RCP outfalls. Stage/discharge relationships were developed for both pipes, to determine the discharge from each pipe based on field-measured depths. The relationships are based on modeled values and are currently being validated by field-measured data. A sample is collected for each limb of a storm by proportioning the appropriate volume of RCP/CMP sample into a sample container, based on each pipes contribution to the total runoff. To determine the appropriate amount of sample to collect from each pipe for each limb, the discharge from the CMP and RCP is computed and totaled. The CMP and RCP discharge is then divided by the total discharge to determine the percent contribution to the total discharge. Once the percent contribution is determined, then volumetric containers are utilized to proportion each pipe sample to create one composite sample. The composite sample is then distributed into the laboratory bottles.

At this time, three storm events (3/19/08, 4/20/08, and 4/26/08) have been sampled utilizing the flow-weighted composite method. Currently, no automated equipment is available for the RCP. Level, pH, and temperature are taken manually during sampled events. All of the flow data and discharge characteristics for each outfall pipe are recorded during the storm event into a laptop spreadsheet that automatically calculates the correct sample proportions. General notes, field-measured velocity data, and a hydrograph are also recorded on the laptop spreadsheet during the storm event (see Figure 2).

As discussed in the field on April 10, 2008, KCI feels that this is an appropriate method for maintaining consistency with the historical data, while reducing the costs of sampling and testing both outfalls individually.

If you have any questions or comments, please feel free to contact me at the number below.

Sincerely,

James A. Tomlinson, PE
Project Manager
(410) 316-7864

ND/jt

cc: Christopher Victoria, AACo DPW
Nathan Drescher/KCI

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Proposed Modifications to Sampling Procedures
Church Creek/Parole Plaza NPDES Monitoring 2008
KCI Job Order No. 01-032333.38
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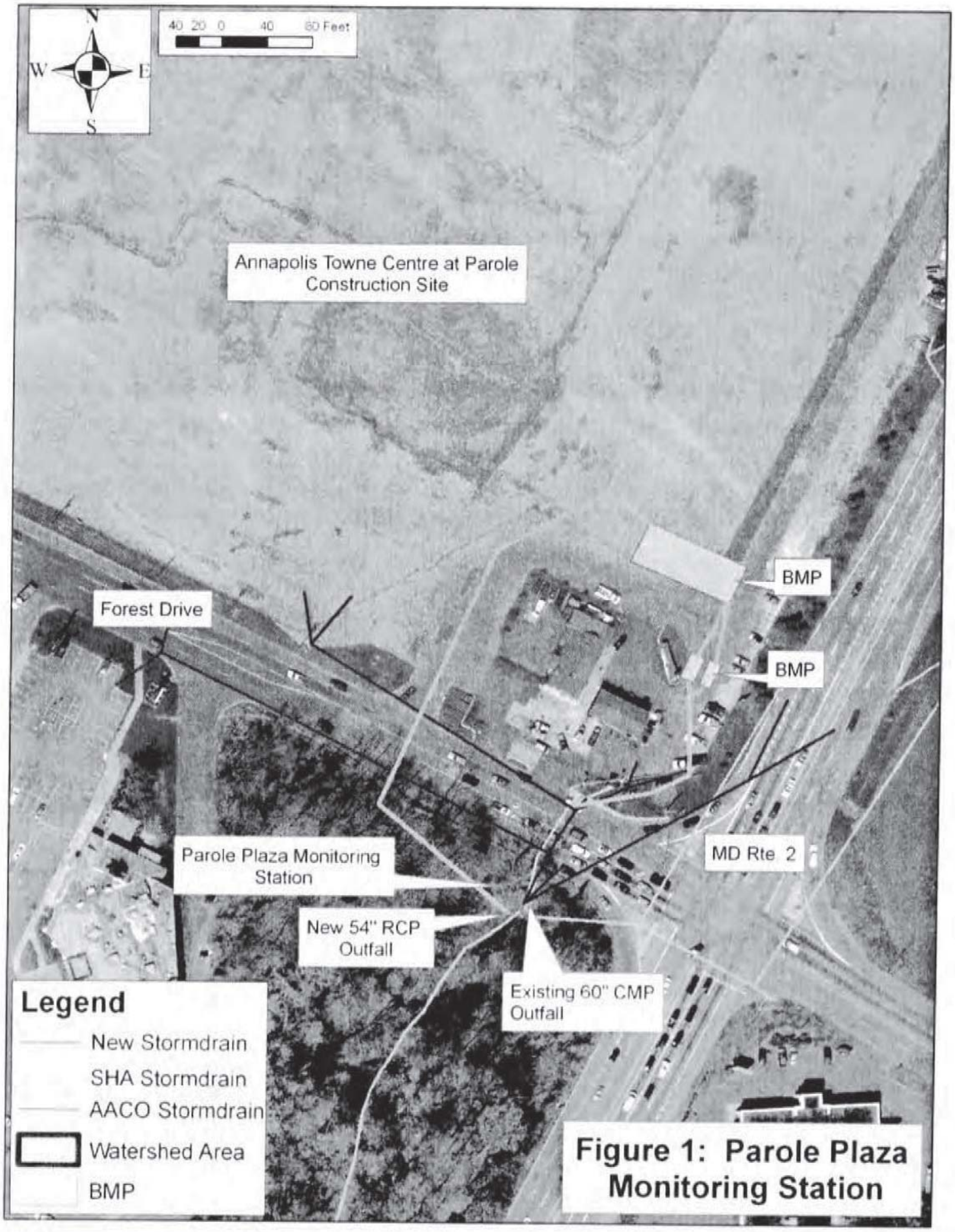

Figure 1: Parole Plaza Monitoring Station

VERSAR

Proposed Modifications to Sampling Procedures
Church Creek/Parole Plaza NPDES Monitoring 2008
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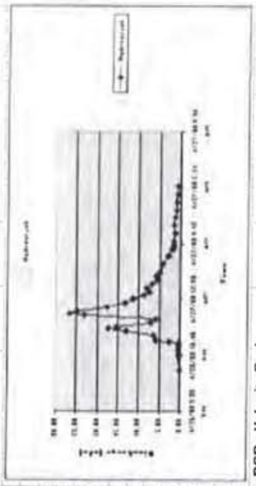
Figure 2

Parole Plaza Combined Hydrograph

Date	Time	CMP Level (ft)	RCP Level (ft)	CMP Q (cfs)	RCP Q (cfs)	RCP pH	RCP Temp Celsius	Combined Q (cfs)	RCP Prop. %	CMP Prop. %
4/26/08	4/26/08 10:30 PM	0.00	0.05	0.00	0.04	-	-	0.04	100	0
4/26/08	4/26/08 10:47 PM	0.00	0.15	0.00	0.19	6.70	15.40	0.19	100	0
4/26/08	4/26/08 10:50 PM	0.00	0.18	0.00	0.26	6.70	15.40	0.26	100	0
4/26/08	4/26/08 10:55 PM	0.00	0.16	0.00	0.21	6.60	15.80	0.21	100	0
4/26/08	4/26/08 11:00 PM	0.00	0.15	0.00	0.19	6.60	15.80	0.19	100	0
4/26/08	4/26/08 11:03 PM	0.10	0.15	0.15	0.19	6.00	16.00	[redacted]	56	44
4/26/08	4/26/08 11:06 PM	0.25	0.40	1.10	1.36	6.00	16.00	2.46	55	45
4/26/08	4/26/08 11:08 PM	0.43	0.52	2.36	2.37	5.80	16.10	5.74	41	59
4/26/08	4/26/08 11:15 PM	0.45	0.55	3.71	2.68	6.20	15.80	6.38	42	58
4/26/08	4/26/08 11:20 PM	0.65	0.75	7.95	5.06	6.10	15.50	13.01	39	61
4/26/08	4/26/08 11:22 PM	0.70	0.95	9.21	8.17	5.90	15.50	17.38	47	53
4/26/08	4/26/08 11:25 PM	0.65	0.90	7.95	7.21	5.90	15.60	15.26	48	52
4/26/08	4/26/08 11:30 PM	0.43	0.65	3.36	3.79	6.90	15.60	7.14	53	47
4/26/08	4/26/08 11:35 PM	0.40	0.58	2.85	2.98	7.00	15.60	5.83	51	49
4/26/08	4/26/08 11:40 PM	0.80	0.93	15.45	7.83	6.90	15.60	23.28	34	66
4/26/08	4/26/08 11:42 PM	0.85	1.20	13.73	12.36	7.00	15.60	[redacted]	48	52
4/26/08	4/26/08 11:45 PM	0.80	1.10	13.13	11.55	6.90	15.60	24.67	47	53
4/26/08	4/26/08 11:50 PM	0.72	0.93	9.79	7.83	7.10	15.80	17.62	44	56
4/26/08	4/26/08 11:55 PM	0.62	0.83	7.19	6.22	7.10	15.80	13.40	46	54
4/27/08	4/27/08 12:00 AM	0.57	0.77	6.04	5.34	7.20	15.30	11.38	47	53
4/27/08	4/27/08 12:05 AM	0.51	0.68	4.77	4.10	7.10	15.40	8.90	46	54
4/27/08	4/27/08 12:10 AM	0.46	0.64	3.88	3.66	7.40	15.30	7.53	49	51
4/27/08	4/27/08 12:15 AM	0.48	0.65	4.22	3.78	7.20	15.30	7.99	47	53
4/27/08	4/27/08 12:20 AM	0.42	0.65	3.19	3.78	8.00	15.30	6.97	54	46
4/27/08	4/27/08 12:25 AM	0.36	0.60	2.33	3.18	7.90	15.30	5.51	58	42
4/27/08	4/27/08 12:30 AM	0.36	0.60	2.59	3.18	7.80	15.30	5.77	55	45
4/27/08	4/27/08 12:35 AM	0.36	0.55	2.33	2.68	7.60	15.40	5.01	53	47
4/27/08	4/27/08 12:45 AM	0.30	0.55	1.55	2.68	7.30	15.30	4.23	63	37
4/27/08	4/27/08 12:55 AM	0.25	0.45	1.10	1.77	7.20	15.30	2.87	62	38
4/27/08	4/27/08 1:05 AM	0.18	0.40	0.55	1.36	7.30	15.30	1.91	71	29
4/27/08	4/27/08 1:10 AM	0.17	0.27	0.50	1.17	7.20	15.30	1.67	70	30
4/27/08	4/27/08 1:15 AM	0.16	0.35	0.45	1.05	7.40	15.30	[redacted]	70	30
4/27/08	4/27/08 1:25 AM	0.13	0.33	0.30	0.93	7.20	15.30	1.23	76	24
4/27/08	4/27/08 1:35 AM	0.13	0.40	0.30	1.36	7.30	15.30	1.66	82	18
4/27/08	4/27/08 1:45 AM	0.13	0.35	0.30	1.05	7.40	15.30	1.35	78	22
4/27/08	4/27/08 1:55 AM	0.13	0.30	0.30	0.74	7.20	15.30	1.04	71	29
4/27/08	4/27/08 2:05 AM	0.11	0.30	0.20	0.74	7.60	15.30	0.94	79	21
4/27/08	4/27/08 2:15 AM	0.10	0.25	0.15	0.53	7.30	15.30	0.68	78	22
4/27/08	4/27/08 2:25 AM	0.09	0.25	0.14	0.53	7.40	15.30	0.66	80	20



RCP - Velocity Probe

Depth	Velocity	SNR	Notes

CMP - Velocity Probe

Depth	Velocity	SNR	Notes

Comments

Pipe	Time	Comment
-	9:22 P M	CMP dry, RCP with small baseflow (0.05); Church normal
-	10:19 PM	Started to rain
	10:35 PM	Steady Light Rain/Thunder
	10:47 PM	RCP: Turbid flow
CMP	11:03 PM	smells bad, trash
CMP	11:50 PM	Muddy Water

Storm Event Narratives

- September 12, 2013 – At the Church Creek station, the EMCs of most parameters during the September 12, 2013 storm were greater than the mean annual values for the early months of 2013, except for BOD, TKN, nitrate-nitrite, TPH, and hardness. TPH was not detected in any samples at Church Creek during the event. Since this event was the only storm for this quarter, most EMCs were higher than the overall EMCs for the quarter. Nitrate-nitrite and hardness were lower than the quarterly EMC during the storm and higher during the baseflow sampling event. At the Parole Plaza station, the EMCs of most parameters during the September 12, 2013 storm were greater than the mean annual values for the early months of 2013 except TPH, *E. coli*, and hardness. As was the case at Church Creek, TPH was the only parameter not detected in any samples. Nitrate-nitrite and hardness were lower for the quarterly EMC during the storm than during the baseflow sampling event.

- October 7, 2013 - At the Church Creek station, the EMCs of most parameters during the October 7, 2013 storm were higher than the EMC values for the September 12, 2013 storm, except for TSS, lead, zinc, and hardness. TPH was not detected in any samples at Church Creek during the event. The EMC for pH during this event was neutral at 7.0. Most of the parameter EMCs for this event were higher than the other two fall events except TKN, nitrate-nitrite, zinc, lead and hardness. The same parameters for the fall flow-weighted EMC were high. At the Parole Plaza station, the EMCs of most parameters during the October 7, 2013 storm were lower than the EMC values for the September 12, 2013, except for pH, *E. coli*, and hardness. As was the case at Church Creek, TPH was the only parameter not detected in any samples. EMCs for BOD, nitrate-nitrite, and *E. coli* during this storm were higher than corresponding EMCs for the other two storms monitored this quarter. Lead, BOD, and nitrate-nitrite were higher than the fall flow-weighted EMCs.

- December 6, 2013 – At the Church Creek station, TKN, nitrate-nitrite, zinc, and hardness EMCs for this event were higher than the other two fall events and the quarterly flow-weighted EMCs. TPH was not detected in any samples at Church Creek during the event. At the Parole Plaza station, in contrast, all of the parameter EMCs were lower than the other two events and the quarterly flow-weighted EMCs. As was the case at Church Creek, TPH was the only parameter not detected in any samples.

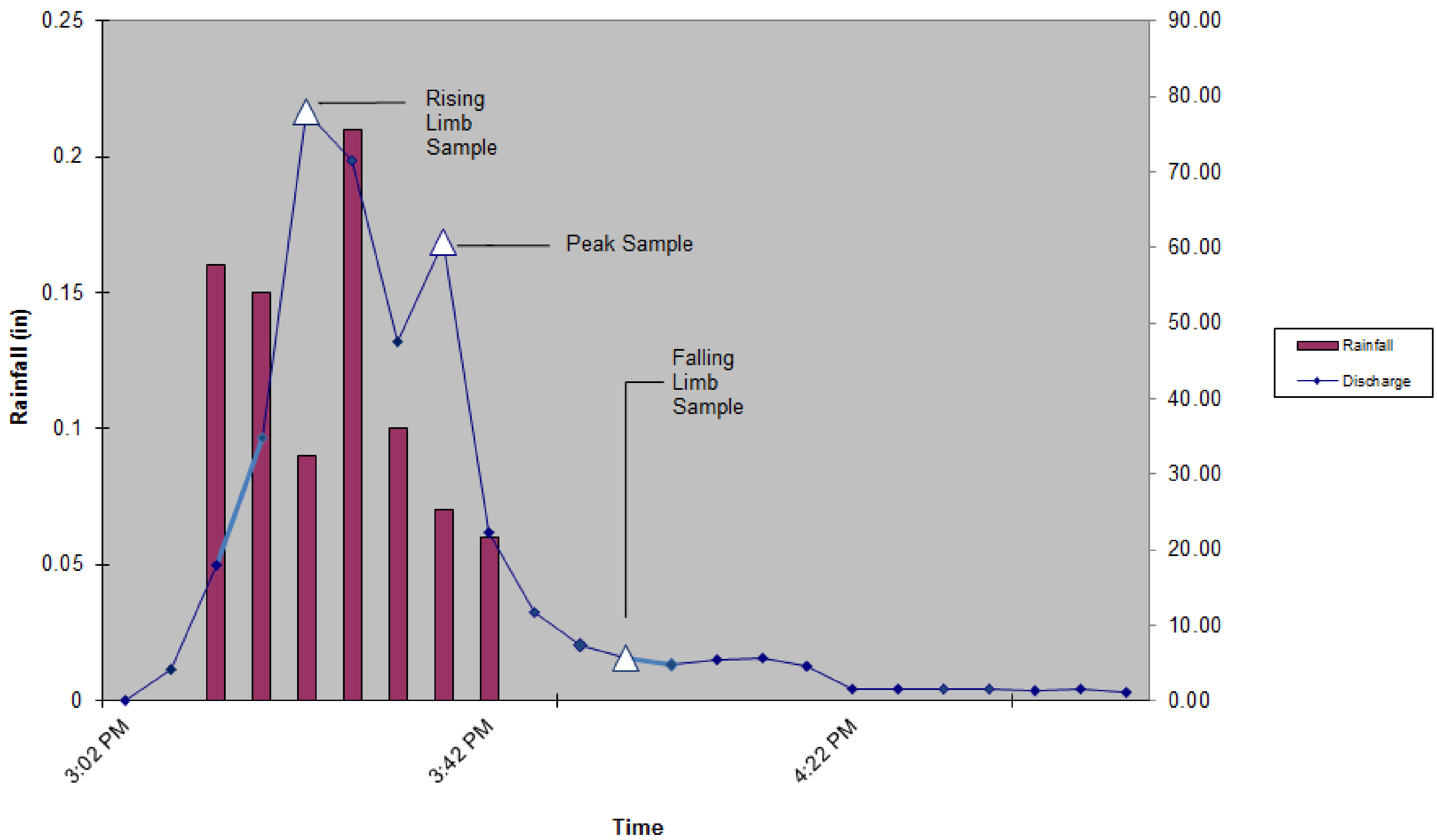
- December 23, 2013 - At Church Creek, the EMCs of all parameters during the December 23, 2013 storm were lower than the other two fall events and the quarterly flow-weighted EMCs with the exception of pH and TSS. TPH was not detected in any samples taken at Church Creek during the event. At the Parole Plaza station, the EMCs of most parameters during the December 23, 2013 storm were higher than the other two events, except for nitrate-nitrite, *E. coli*, and BOD. Concentrations of nitrate-nitrite and *E. coli* were also higher than the quarterly flow-weighted EMCs. As was the case at Church Creek, TPH was not detected in any samples.

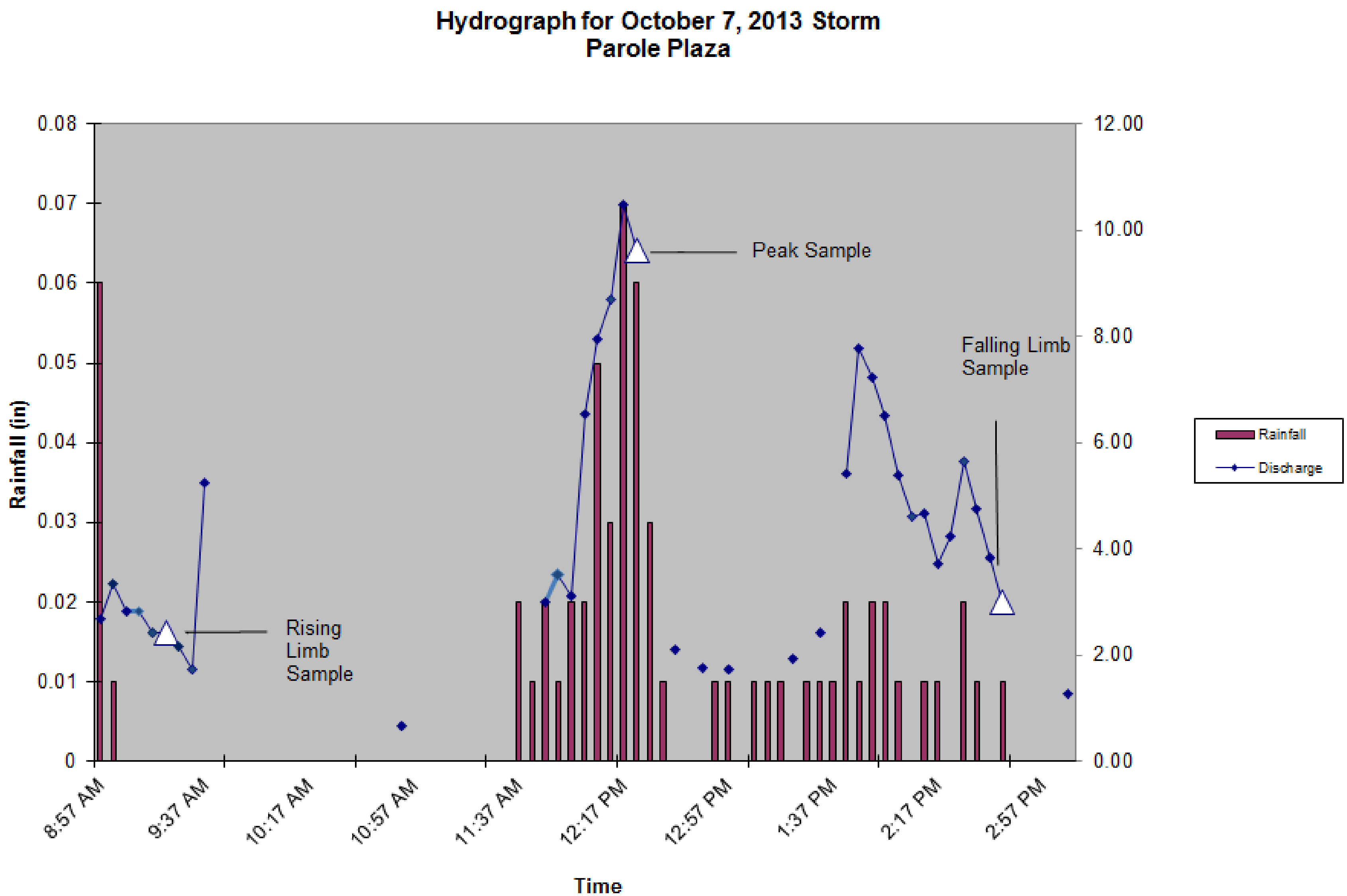
- April 7, 2014 - At the Church Creek station, the EMCs of most parameters during the April 7, 2014 storm were lower than the EMC values for the other storms during the quarter, except for nitrate-nitrite and hardness. TPH was not detected in any samples at Church Creek during the event. At the Parole Plaza station, the EMCs of most parameters during the April 7, 2014 storm were comparable to EMC values for the other storms monitored during the quarter, except for *E. Coli*, which was much lower during this event. As was the case at Church Creek, TPH was the only parameter not detected in any samples.

- May 27, 2014 - At the Church Creek station, EMCs for BOD and TKN during the May 27, 2014 storm were higher than the EMC values for the other storms monitored during the quarter. EMCs for nitrite-nitrate, copper, and zinc were lower than EMCs for the other storms monitored during the quarter. TPH was not detected in any samples at Church Creek during the event. At the Parole Plaza station, the EMCs of BOD, TKN, and total phosphorus were higher than EMCs for other storms monitored during the quarter. The EMC for pH was the lowest during this storm. As was the case at Church Creek, TPH was the only parameter not detected in any samples.

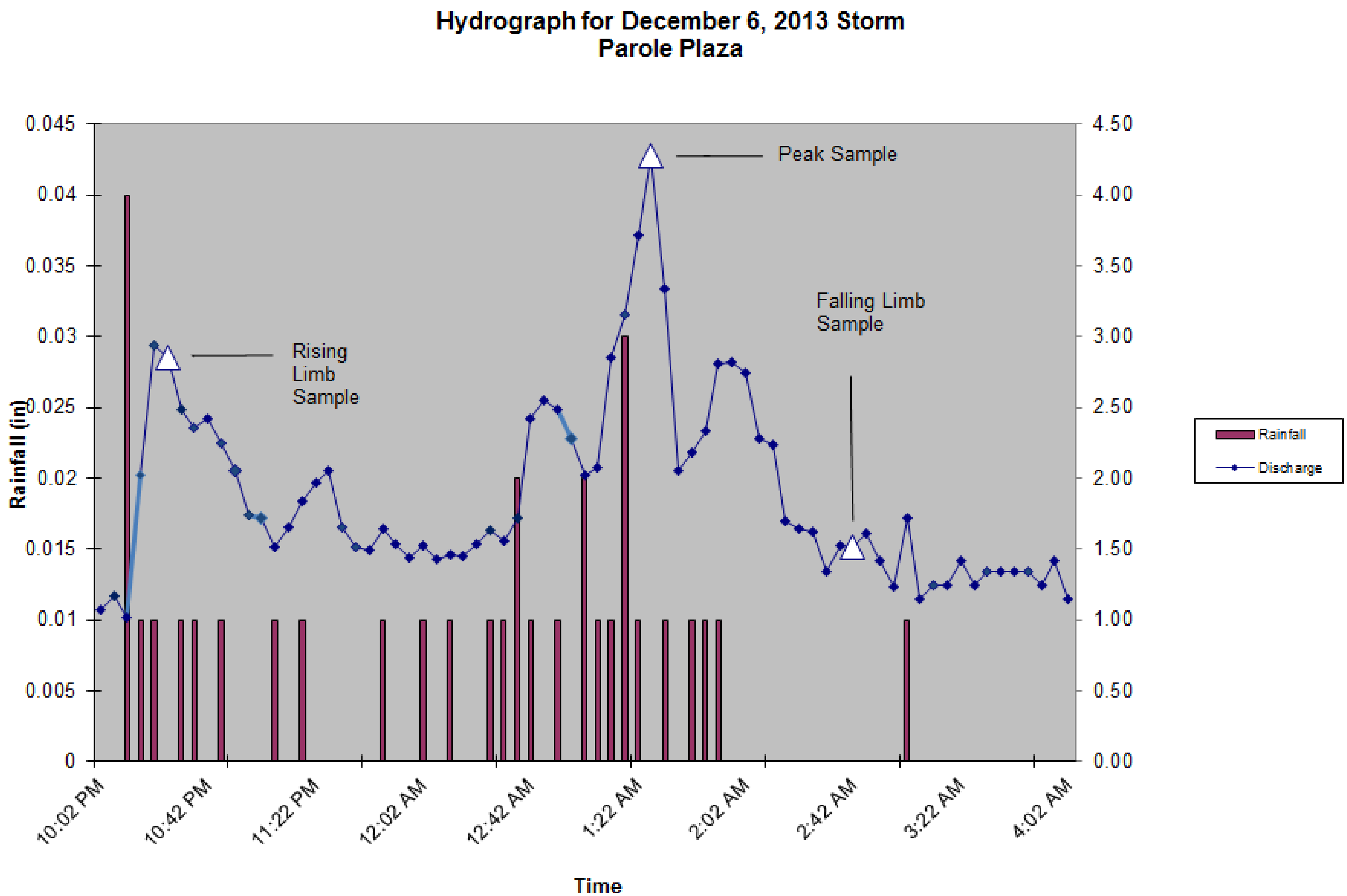
- June 19, 2014 - At the Church Creek station, the EMCs of most parameters, including all of the metals, during the June 19, 2014 storm were higher than the EMC values for the other storms monitored during the quarter. TPH was not detected in any samples at Church Creek during the event. At the Parole Plaza station, the EMCs of most parameters during the June 19, 2014 storm were lower than the EMC values for other storms monitored during the quarter, except for temperature, pH, and *E. coli*, which were the highest. As was the case at Church Creek, TPH was the only parameter not detected in any samples.

Hydrograph for September 12, 2013 Storm
Parole Plaza

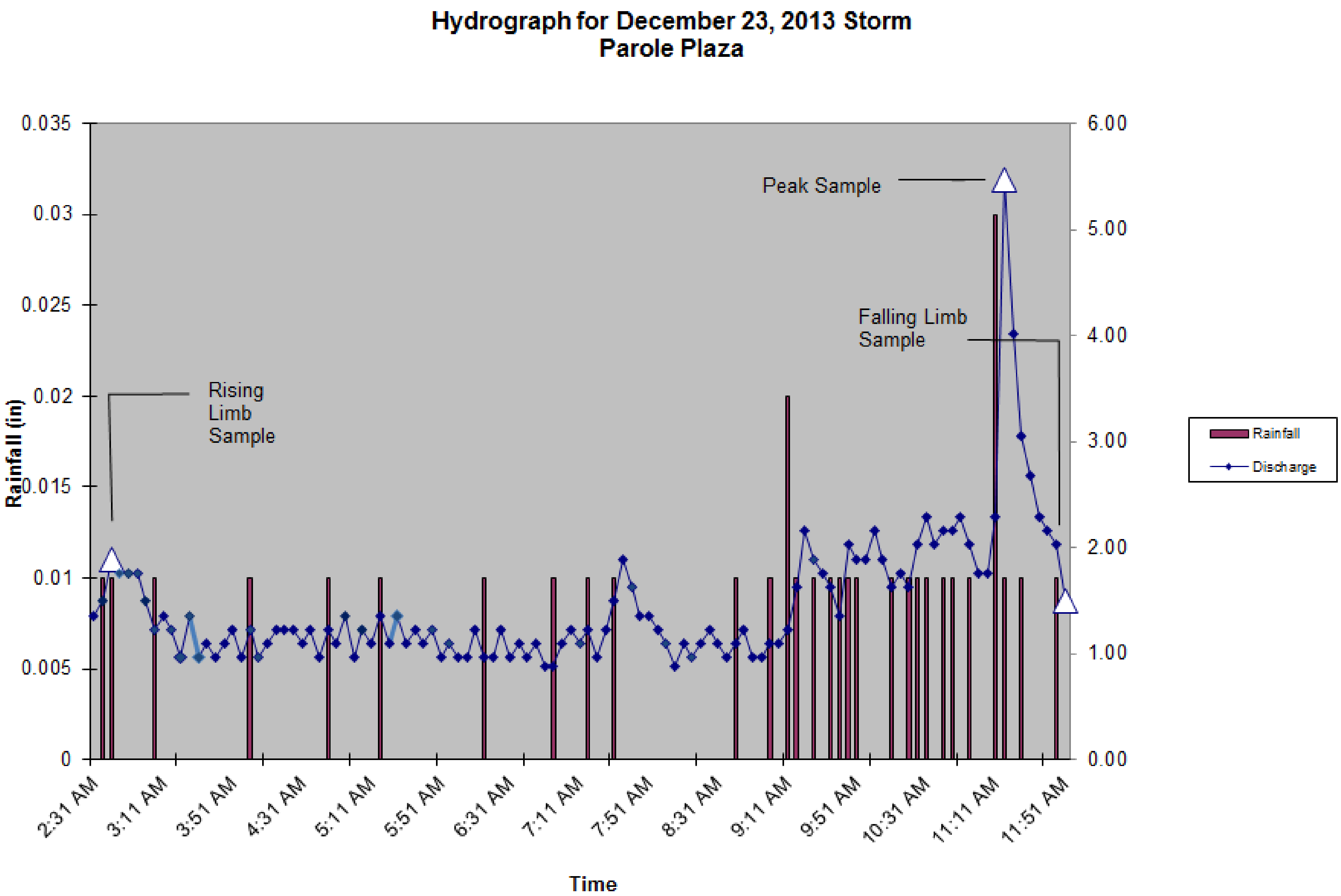




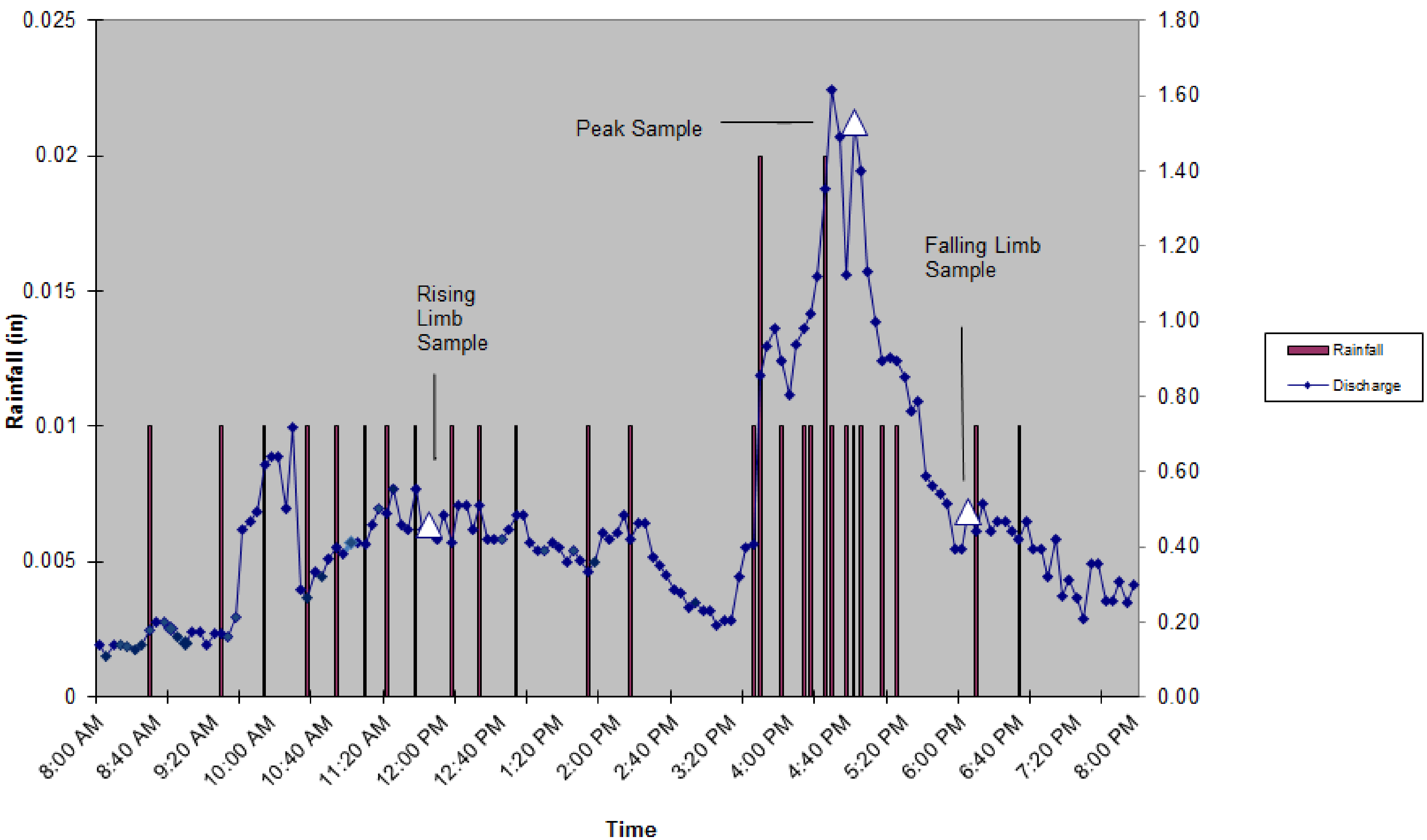
Hydrograph for October 7, 2013 Storm
Parole Plaza
Rainfall (in)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Peak Sample
Rising Limb Sample
Falling Limb Sample
Rainfall
Discharge
8:57 AM
9:37 AM
10:17 AM
10:57 AM
11:37 AM
12:17 PM
12:57 PM
1:37 PM
2:17 PM
2:57 PM
Time

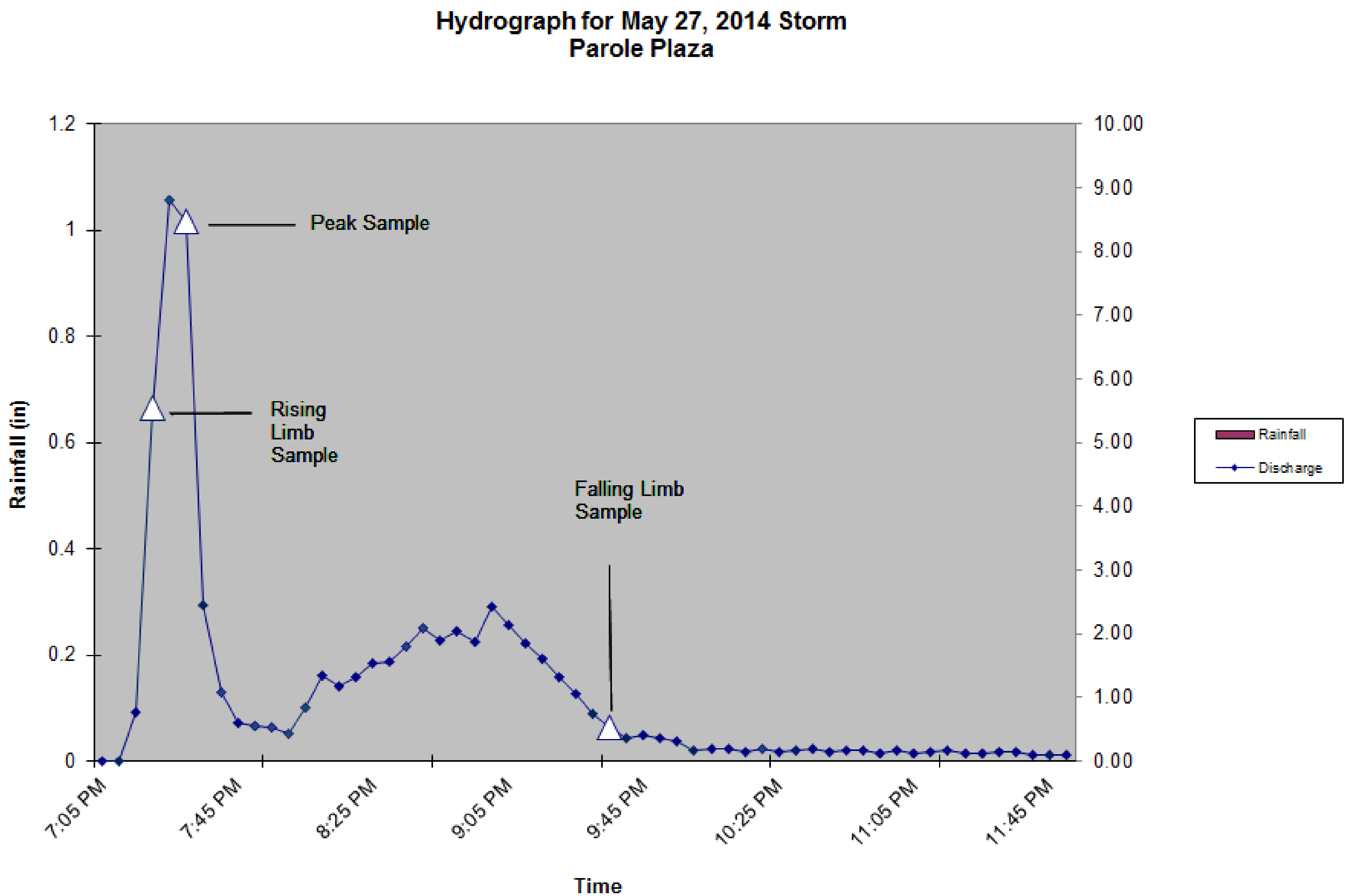


Hydrograph for December 6, 2013 Storm
Parole Plaza
Rainfall (in)
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
Rising Limb Sample
Peak Sample
Falling Limb Sample
10:02 PM
10:42 PM
11:22 PM
12:02 AM
12:42 AM
1:22 AM
2:02 AM
2:42 AM
3:22 AM
4:02 AM
Time
Rainfall
Discharge

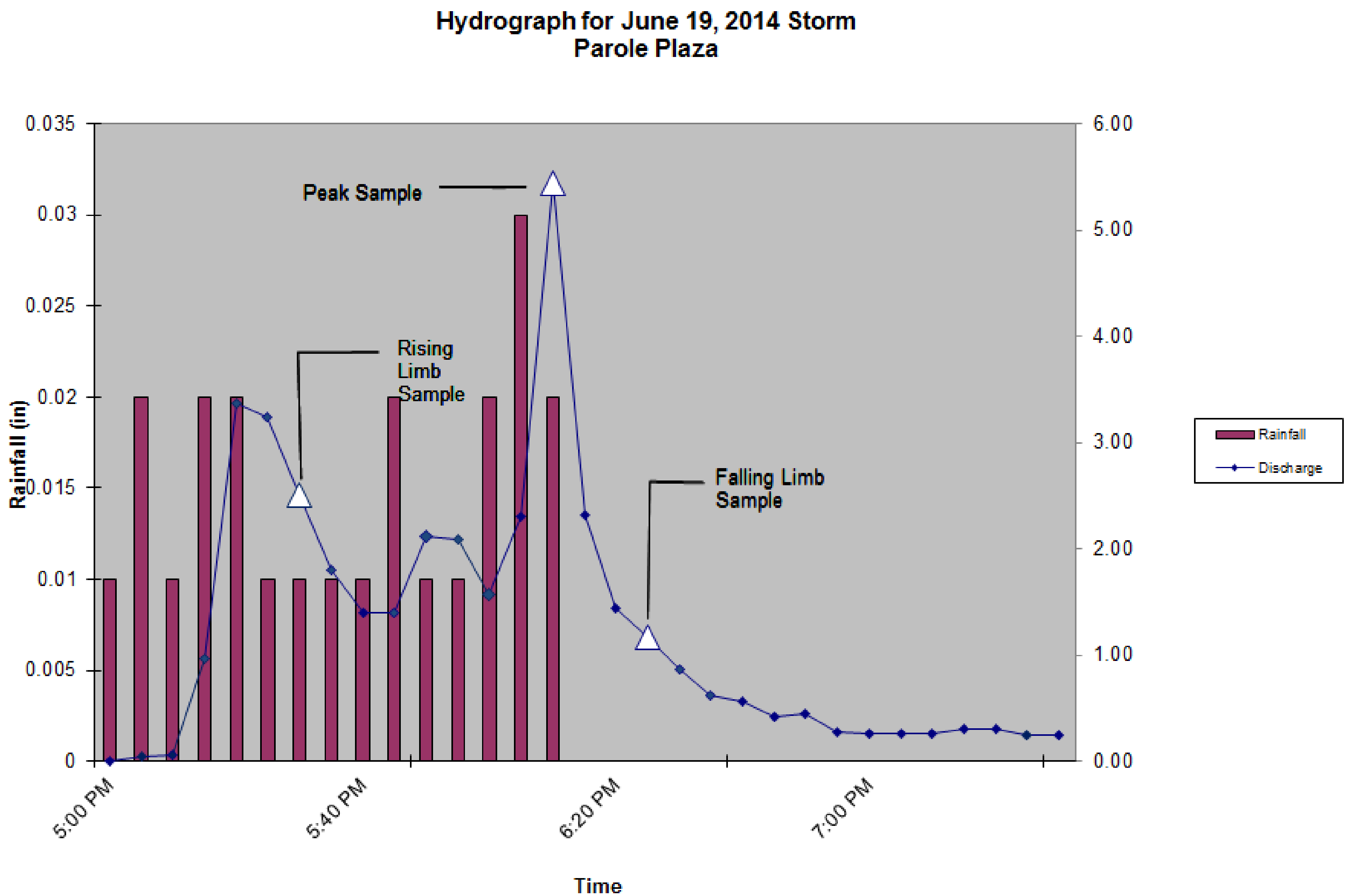

Hydrograph for December 23, 2013 Storm
Parole Plaza
Rainfall (in)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Peak Sample
Falling Limb Sample
Rising Limb Sample
2:31 AM
3:11 AM
3:51 AM
4:31 AM
5:11 AM
5:51 AM
6:31 AM
7:11 AM
7:51 AM
8:31 AM
9:11 AM
9:51 AM
10:31 AM
11:11 AM
11:51 AM
Time
Rainfall
Discharge

Hydrograph for April 7, 2014 Storm
Parole Plaza



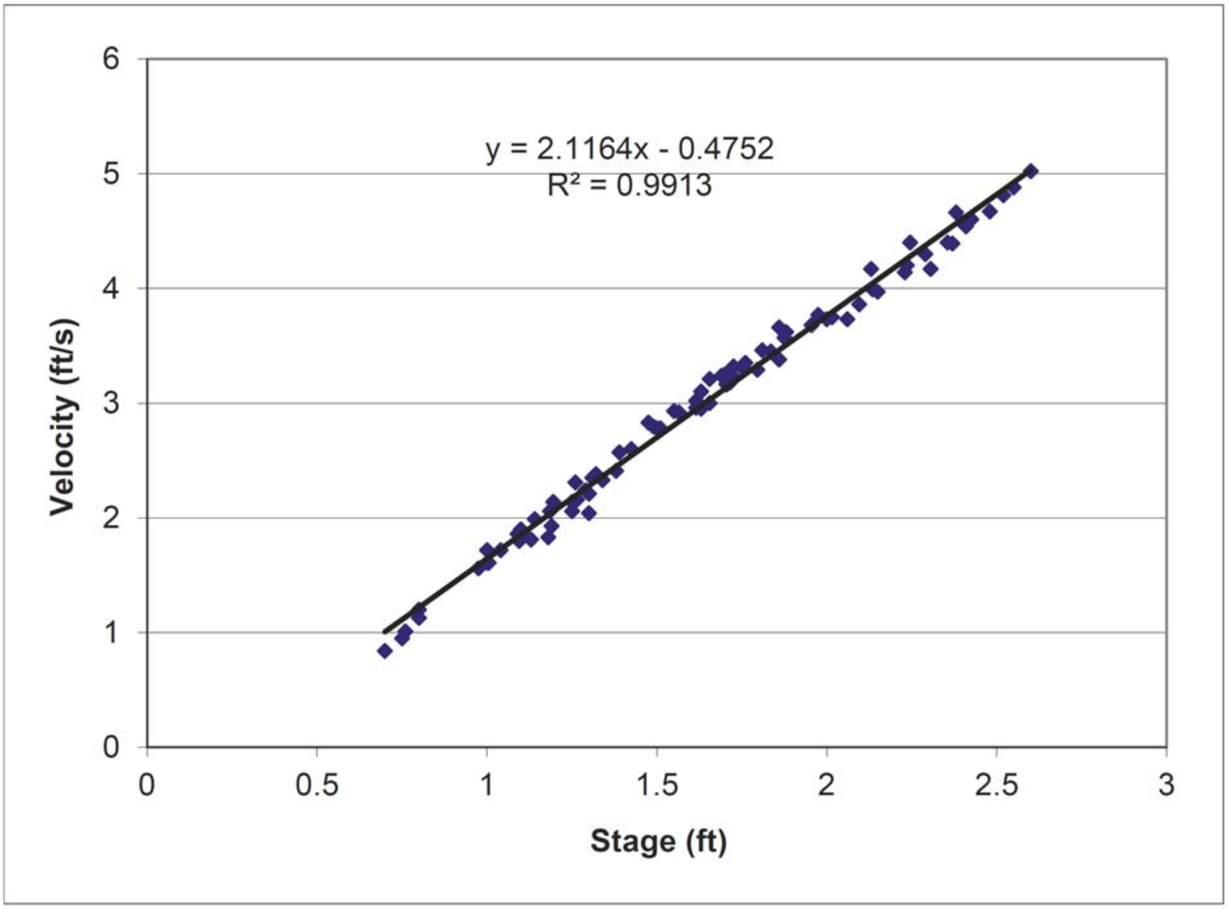


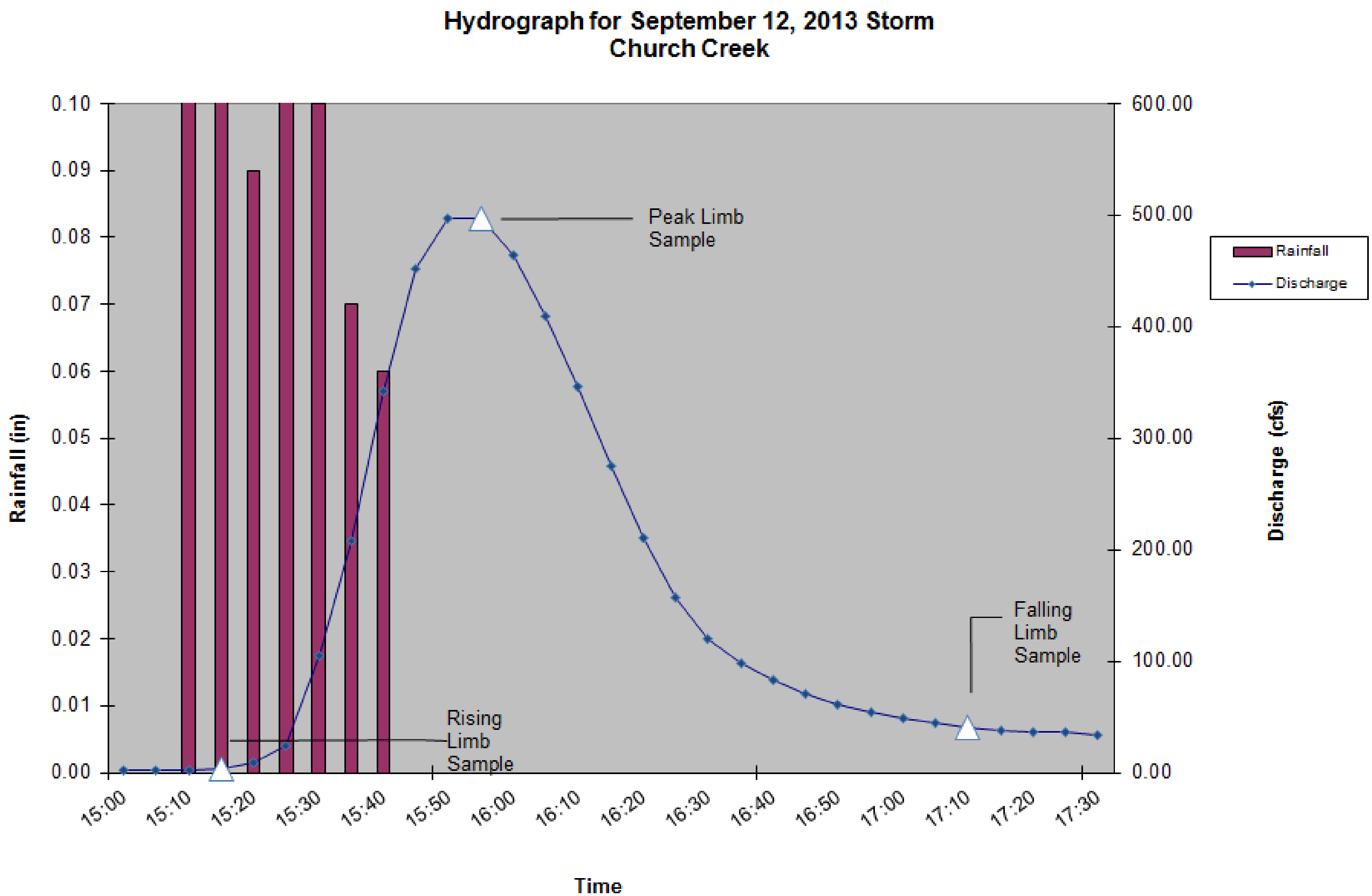
Hydrograph for May 27, 2014 Storm
Parole Plaza
Rainfall (in)
1.2
1
0.8
0.6
0.4
0.2
0
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Peak Sample
Rising Limb Sample
Falling Limb Sample
Rainfall
Discharge
7:05 PM
7:45 PM
8:25 PM
9:05 PM
9:45 PM
10:25 PM
11:05 PM
11:45 PM
Time


Hydrograph for June 19, 2014 Storm
Parole Plaza
Peak Sample
Rising Limb Sample
Falling Limb Sample
Rainfall (in)
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
6.00
5.00
4.00
3.00
2.00
1.00
0.00
5:00 PM
5:40 PM
6:20 PM
7:00 PM
Time
Rainfall
Discharge

Church Creek Discharge Rating Table

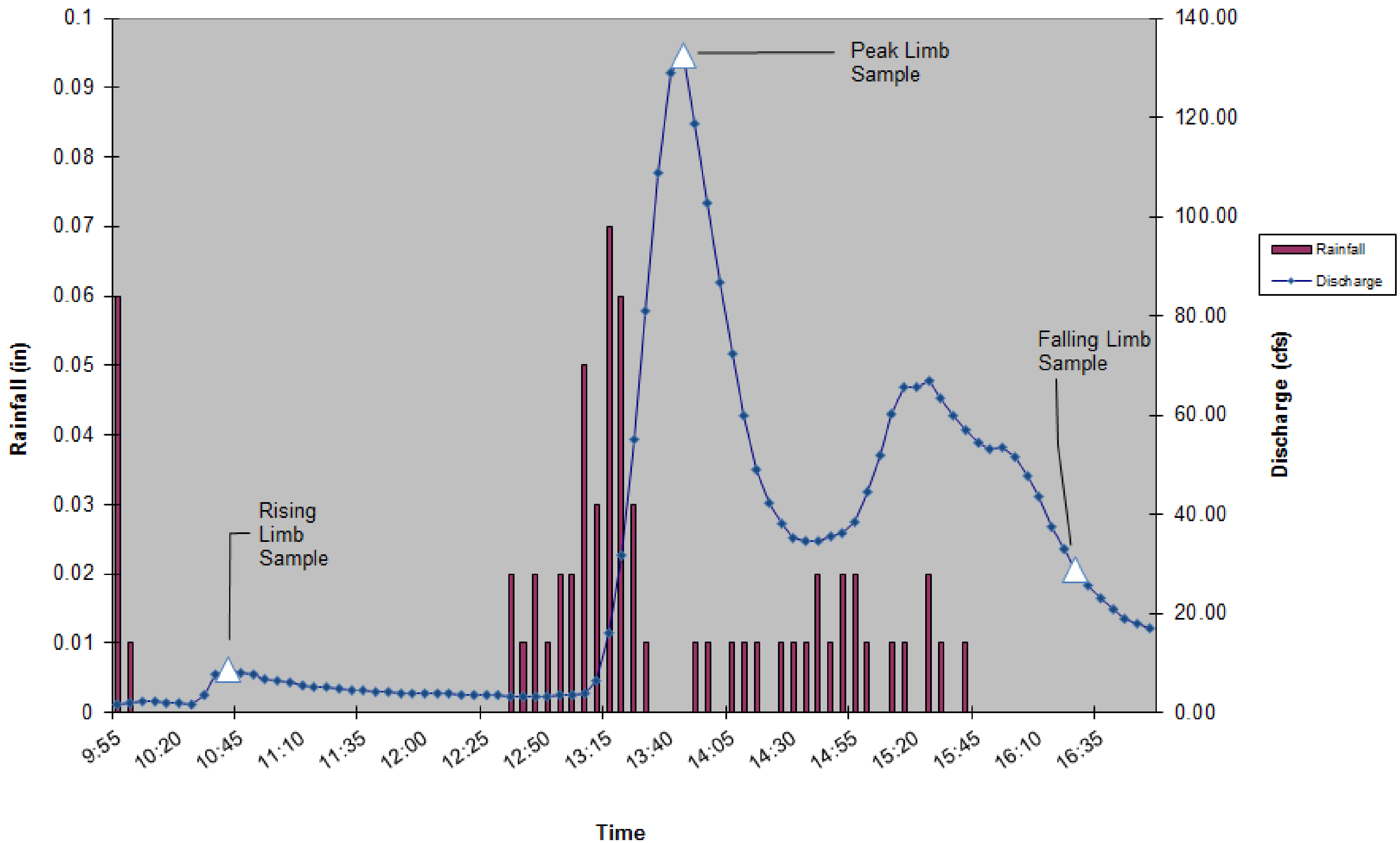
Stage (ft)	Flow Area (ft^2)	Wetted Perimeter (ft)	Top Width (ft)	Velocity, (ft/s)	Discharge (cfs)
0.0	0	0	0	0.00	0.00
0.1	0.21	2.77	2.75	0.00	0.00
0.2	0.53	3.62	3.57	0.00	0.00
0.3	0.91	4.03	3.93	0.16	0.15
0.4	1.31	4.36	4.19	0.37	0.49
0.5	1.75	4.83	4.58	0.58	1.02
0.6	2.22	5.09	4.73	0.79	1.76
0.7	2.70	5.34	4.88	1.01	2.72
0.8	3.20	5.73	5.20	1.22	3.90
0.9	3.74	6.14	5.54	1.43	5.35
1.0	4.31	6.48	5.81	1.64	7.07
1.1	4.90	6.75	5.98	1.85	9.08
1.2	5.50	7.01	6.16	2.06	11.35
1.3	6.13	7.28	6.33	2.28	13.95
1.4	6.77	7.53	6.49	2.49	16.84
1.5	7.43	7.80	6.66	2.70	20.06
1.6	8.10	8.08	6.86	2.91	23.58
1.7	8.80	8.37	7.06	3.12	27.48
1.8	9.51	8.65	7.26	3.33	31.71
1.9	10.25	8.93	7.44	3.55	36.35
2.0	11.00	9.15	7.52	3.76	41.33
2.1	11.75	9.35	7.54	3.97	46.64
2.2	12.51	9.55	7.57	4.18	52.30
2.3	13.26	9.75	7.60	4.39	58.24
2.4	14.03	9.96	7.63	4.60	64.60
2.5	14.79	10.16	7.65	4.82	71.23
2.6	15.56	10.36	7.68	5.03	78.23
2.7	16.33	10.56	7.71	5.24	85.55
2.8	17.10	10.76	7.73	5.45	93.21
2.9	17.87	10.96	7.76	5.66	101.19
3.0	18.65	11.17	7.79	5.87	109.55
3.1	19.43	11.37	7.81	6.09	118.24
3.2	20.21	11.57	7.84	6.30	127.27
3.3	21.00	11.77	7.87	6.51	136.69
3.4	21.79	11.97	7.89	6.72	146.44
3.5	22.58	12.18	7.92	6.93	156.53
3.6	23.37	12.38	7.95	7.14	166.95
3.7	24.17	12.58	7.98	7.36	177.78

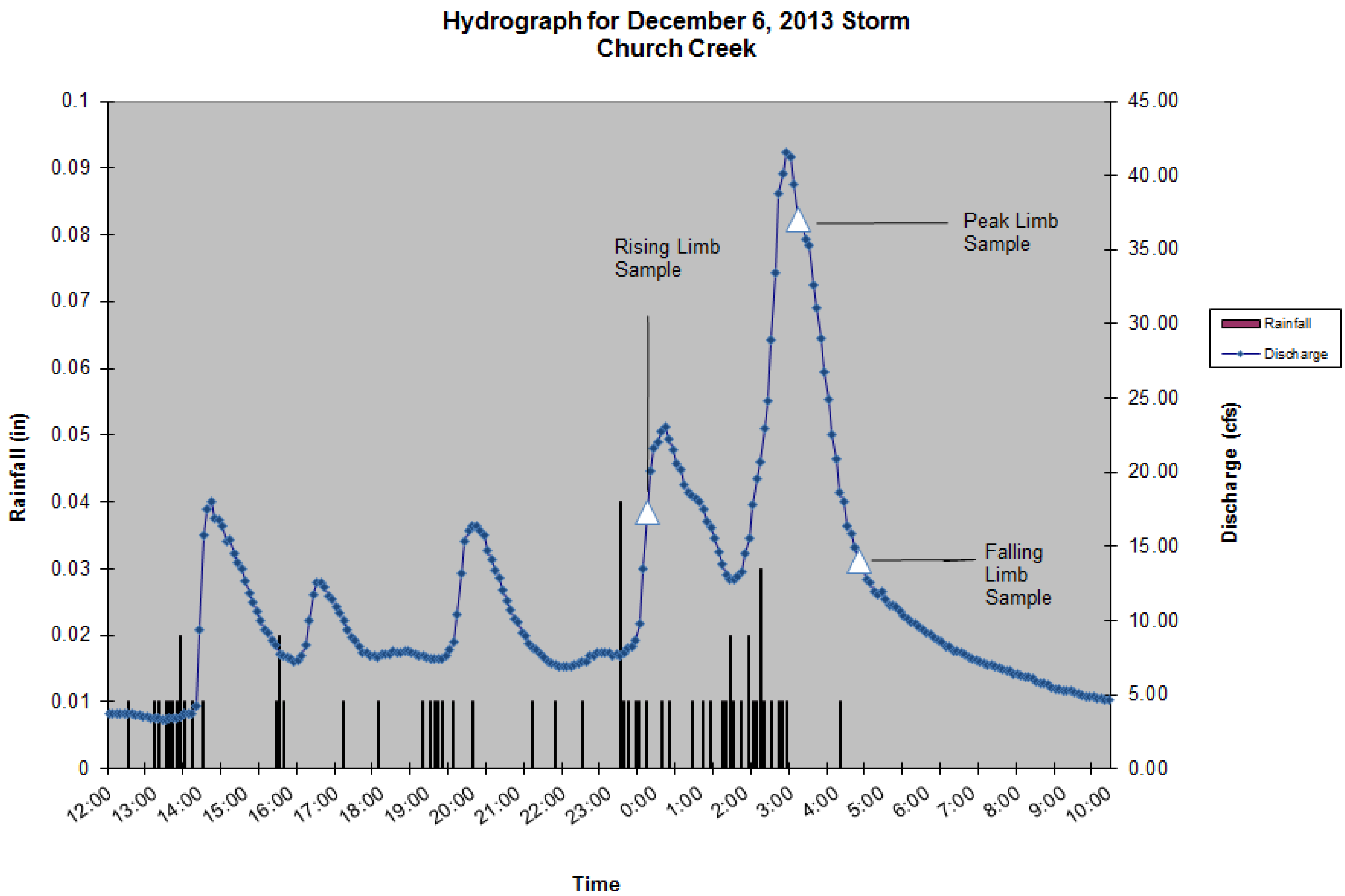

y = 2.1164x - 0.4752
R² = 0.9913
Velocity (ft/s)
Stage (ft)
0
1
2
3
4
5
6
0
0.5
1
1.5
2
2.5
3



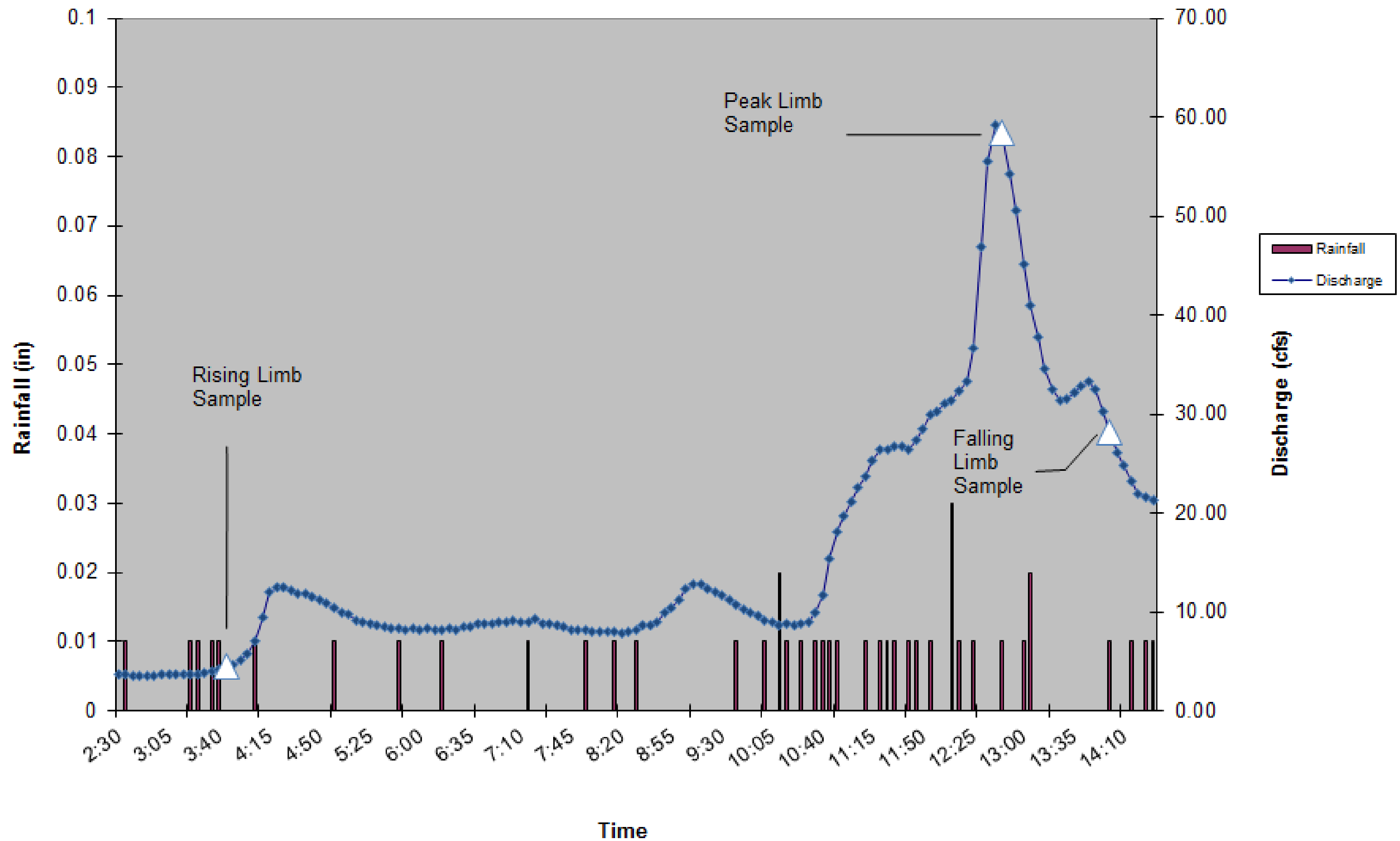
Hydrograph for September 12, 2013 Storm
Church Creek
Rainfall (in)
0.10
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Discharge (cfs)
600.00
500.00
400.00
300.00
200.00
100.00
0.00
Peak Limb Sample
Rising Limb Sample
Falling Limb Sample
Rainfall
Discharge
15:00
15:10
15:20
15:30
15:40
15:50
16:00
16:10
16:20
16:30
16:40
16:50
17:00
17:10
17:20
17:30
Time

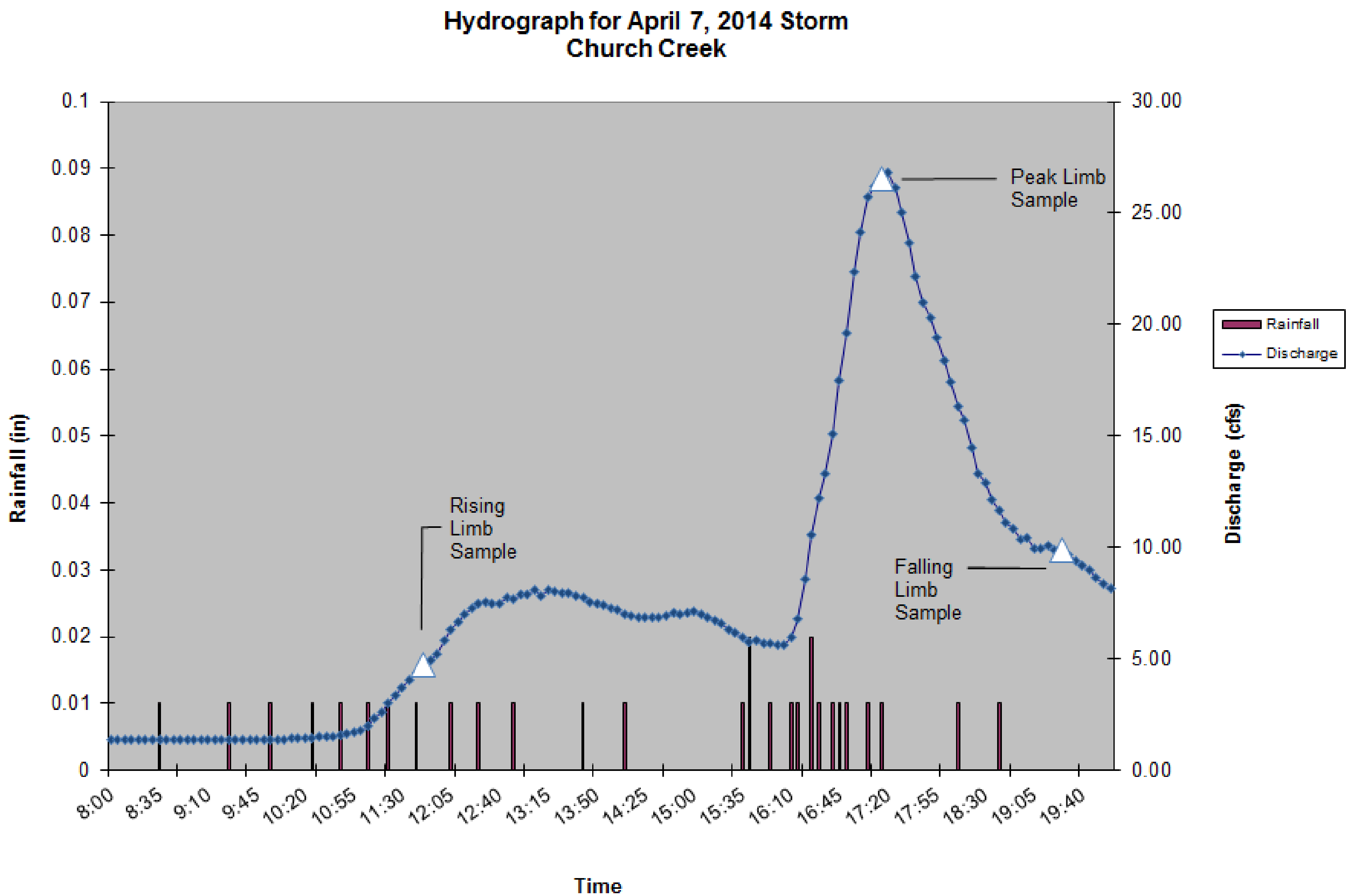
Hydrograph for October 7, 2013 Storm
Church Creek

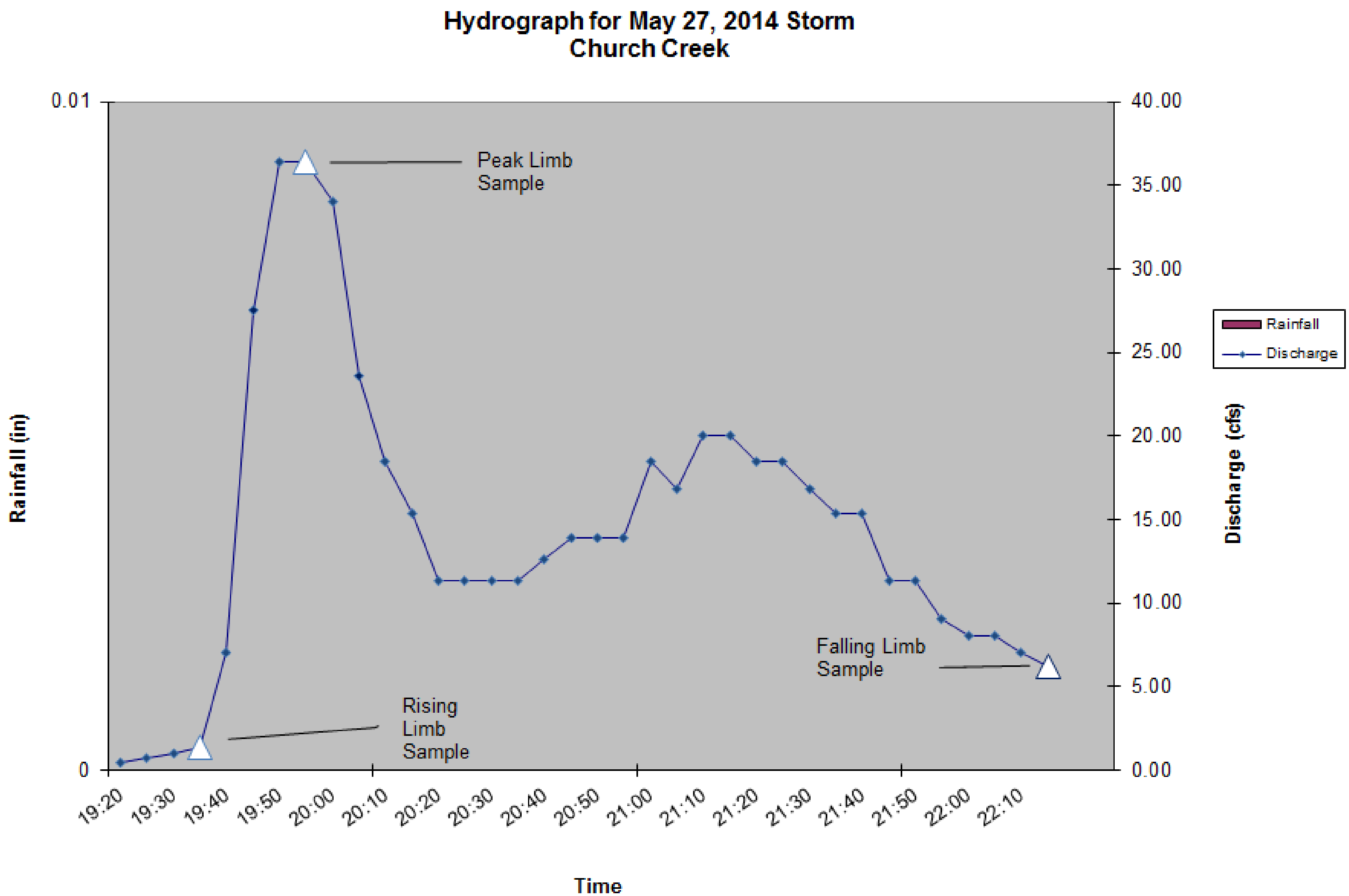



Hydrograph for December 6, 2013 Storm
Church Creek
Rainfall (in)
Discharge (cfs)
Time
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
Rising Limb Sample
Peak Limb Sample
Falling Limb Sample
Rainfall
Discharge

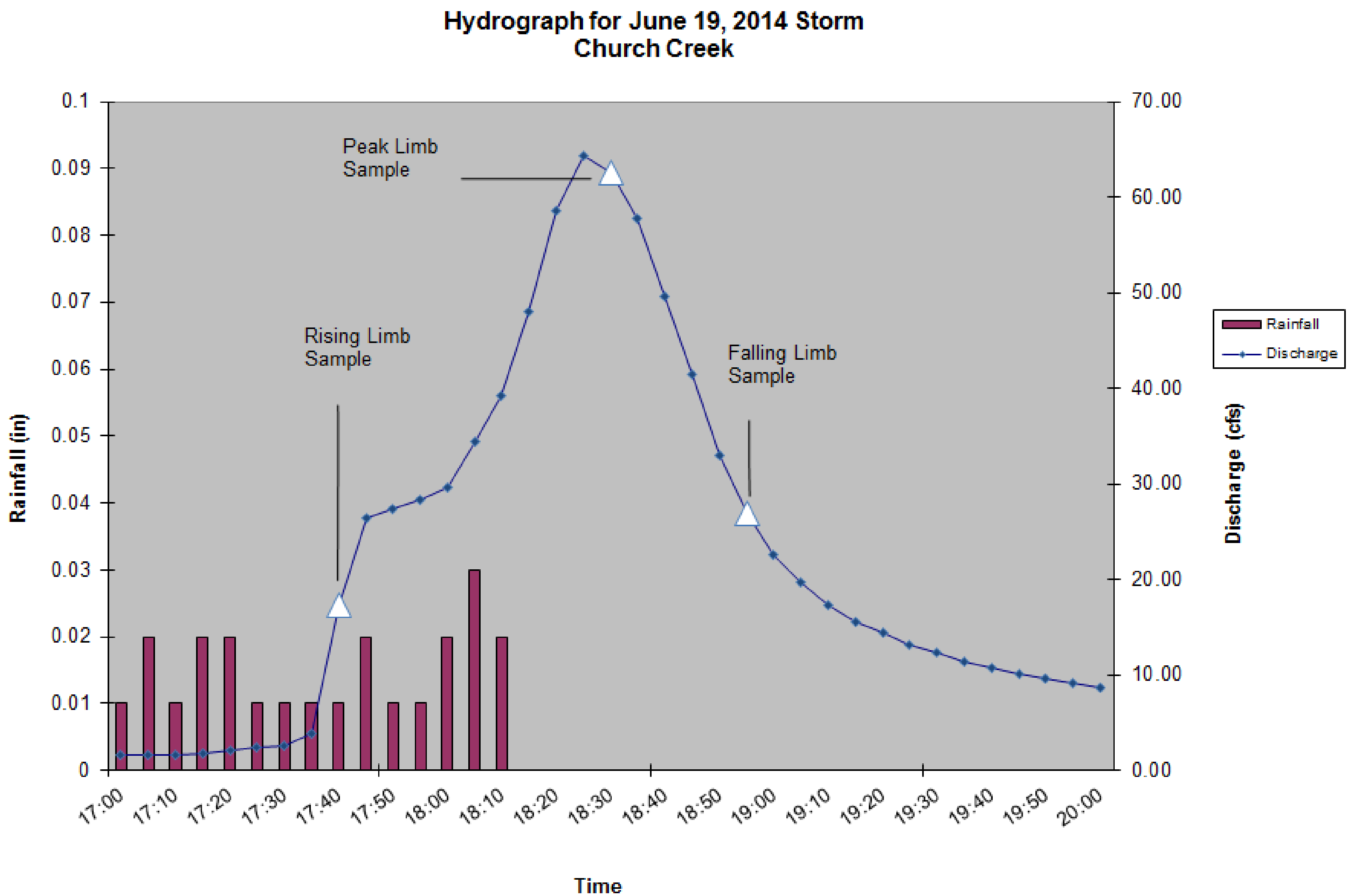
Hydrograph for December 23, 2013 Storm
Church Creek




Hydrograph for April 7, 2014 Storm
Church Creek
Rainfall (in)
Discharge (cfs)
Time
Rising Limb Sample
Peak Limb Sample
Falling Limb Sample
Rainfall
Discharge
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
0.00
5.00
10.00
15.00
20.00
25.00
30.00
8:00
8:35
9:10
9:45
10:20
10:55
11:30
12:05
12:40
13:15
13:50
14:25
15:00
15:35
16:10
16:45
17:20
17:55
18:30
19:05
19:40



Hydrograph for May 27, 2014 Storm
Church Creek
0.01
0
Rainfall (in)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Discharge (cfs)
Peak Limb
Sample
Rising
Limb
Sample
Falling Limb
Sample
Rainfall
Discharge
19:20
19:30
19:40
19:50
20:00
20:10
20:20
20:30
20:40
20:50
21:00
21:10
21:20
21:30
21:40
21:50
22:00
22:10
Time



Hydrograph for June 19, 2014 Storm
Church Creek
Peak Limb
Sample
Rising Limb
Sample
Falling Limb
Sample
Rainfall (in)
Discharge (cfs)
Time
Rainfall
Discharge
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
17:00
17:10
17:20
17:30
17:40
17:50
18:00
18:10
18:20
18:30
18:40
18:50
19:00
19:10
19:20
19:30
19:40
19:50
20:00

APPENDIX B

MASTER TAXA LIST

Order	Family	Genus	Final ID	FFG(a)	Habit(b)	Tolerance Value(c)
Amphipoda	Crangonyctidae	Crangonyx	Crangonyx	Collector	sp	6.7
Amphipoda	Gammaridae	Gammarus	Gammarus	Shredder	sp	6.7
Basommatophora	Lymnaeidae		Lymnaeidae	Scraper	cb	6.9
Basommatophora	Lymnaeidae	Fossaria	Fossaria	Scraper	cb	6.9
Basommatophora	Physidae	Physa	Physa	Scraper	cb	7
Coleoptera	Dryopidae	Helichus	Helichus	Scraper	cn	6.4
Coleoptera	Dytiscidae		Dytiscidae	Predator	sw, dv	5.4
Coleoptera	Elmidae	Stenelmis	Stenelmis	Scraper	cn	7.1
Diptera	Chironomidae	Chaetocladius	Chaetocladius	Collector	sp	7
Diptera	Chironomidae	Chironomini	Chironomini			5.9
Diptera	Chironomidae	Chironomus	Chironomus	Collector	bu	4.6
Diptera	Chironomidae	Conchapelopia	Conchapelopia	Predator	sp	6.1
Diptera	Chironomidae	Cricotopus	Cricotopus	Shredder	cn, bu	9.6
Diptera	Chironomidae	Dicrotendipes	Dicrotendipes	Collector	bu	9
Diptera	Chironomidae	Hydrobaenus	Hydrobaenus	Scraper	sp	7.2
Diptera	Chironomidae	Micropsectra	Micropsectra	Collector	cb, sp	2.1
Diptera	Chironomidae	Orthocladius	Orthocladius	Collector	sp, bu	9.2
Diptera	Chironomidae	Parametriocnemus	Parametriocnemus	Collector	sp	4.6
Diptera	Chironomidae	Paraphaenocladius	Paraphaenocladius	Collector	sp	4
Diptera	Chironomidae	Paratanytarsus	Paratanytarsus	Collector	sp	7.7
Diptera	Chironomidae	Phaenopsectra	Phaenopsectra	Collector	cn	8.7
Diptera	Chironomidae	Polypedilum	Polypedilum	Shredder	cb, cn	6.3
Diptera	Chironomidae	Procladius	Procladius	Predator	sp	1.2
Diptera	Chironomidae	Prodiamesa	Prodiamesa	Collector	bu, sp	6.6
Diptera	Chironomidae	Rheotanytarsus	Rheotanytarsus	Filterer	cn	7.2
Diptera	Chironomidae	Tanypodinae	Tanypodinae	Predator		7.5
Diptera	Chironomidae	Thienemannimyia group	Thienemannimyia group	Predator	sp	8.2
Diptera	Chironomidae	Zavrelimyia	Zavrelimyia	Predator	sp	5.3
Diptera	Empididae		Empididae	Predator	sp, bu	7.5
Diptera	Empididae	Hemerodromia	Hemerodromia	Predator	sp, bu	7.9
Diptera	Simuliidae	Stegopterna	Stegopterna	Filterer	cn	2.4
Diptera	Stratiomyidae		Stratiomyidae	Collector		
Diptera	Tipulidae		Tipulidae	Predator	bu, sp	4.8
Diptera	Tipulidae	Helius	Helius	Predator	sp, bu	3.6
Diptera	Tipulidae	Limnophila	Limnophila	Predator	bu	4.8
Haplotaxida	Enchytraeidae		Enchytraeidae	Collector	bu	9.1
Hemiptera	Noteridae		Noteridae			
Hoplonemertea	Tetrastemmatidae	Prostoma	Prostoma	Predator		7.3
Isopoda	Asellidae	Caecidotea	Caecidotea	Collector	sp	2.6
Lumbriculida	Lumbriculidae		Lumbriculidae	Collector	bu	6.6
Megaloptera	Corydalidae	Nigronia	Nigronia	Predator	cn, cb	1.4
Odonata	Calopterygidae	Calopteryx	Calopteryx	Predator	cb	8.3
Odonata	Coenagrionidae	Argia	Argia	Predator	cn, cb, sp	9.3
Odonata	Coenagrionidae	Ischnura	Ischnura	Predator	cb	9
Odonata	Gomphidae		Gomphidae	Predator	bu	2.2
Trichoptera	Hydropsychidae	Cheumatopsyche	Cheumatopsyche	Filterer	cn	6.5
Trichoptera	Limnephilidae		Limnephilidae	Shredder	cb, sp, cn	3.4
Trichoptera	Limnephilidae	Pycnopsyche	Pycnopsyche	Shredder	sp, cb, cn	3.1
Trichoptera	Molannidae	Molanna	Molanna	Scraper	sp, cn	6
Trichoptera	Philopotamidae	Chimarra	Chimarra	Filterer	cn	4.4
Trichoptera	Polycentropodidae	Polycentropus	Polycentropus	Filterer	cn	1.1
Trichoptera	Psychomyiidae		Psychomyiidae			4.9
Tricladida	Dugesiidae	Girardia	Girardia	Predator	sp	9.3
Tubificida	Tubificidae		Tubificidae	Collector	cn	8.4
Veneroida	Pisidiidae		Pisidiidae	Filterer		6.5
Veneroida	Pisidiidae	Pisidium	Pisidium	Filterer	bu	5.7

(a) Functional Feeding Group
(b) Primary habit or form of locomotion, includes bu - burrower, cn - clinger, cb - climber, sk - skater, sp - sprawler, sw – swimmer information for the particular taxa was not available.
(c) Tolerance Values, based on Hilsenhoff, modified for Maryland; na indicates information for the particular taxa was not available.

APPENDIX C

BIOLOGICAL ASSESSMENT RESULTS

Church Creek Site CC-01

Sampled: 3/14/2014

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Very Poor
BIBI Score	1.57

Metric	Value	Score
Total Taxa	4	1
EPT Taxa	0	1
Number Ephemeroptera	0	1
% Intolerant to Urban	0	1
% Ephemeroptera	0	1
Scraper Taxa	0	1
% Climbers	44.44	5

Benthic Macroinvertebrate Taxa List

Taxa	Count
Argia	8
Noteridae	1
Tipulidae	1
Tubificidae	8

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Degraded
PHI Score	65.85

Metric	Score
Drainage area (acres)	70.40
Remoteness	18.60
Percent Shading	68.32
Epifaunal Substrate	63.35
Instream Habitat	81.54
Instream Wood Debris	100.00
Bank Stability	63.28

Rapid Bioassessment Protocal

Narrative Rating	Partially Supporting
RBP Score	70

Metric	Score
Epifaunal Substrate / Cover	9
Embeddedness	9
Velocity / Depth Regime	7
Sediment Deposition	9
Channel Flow Status	14
Channel Alteration	19
Frequency of Riffles	16
Bank Stability	5(Left)/4(Right)
Vegetative Protection	5(Left)/6(Right)
Riparian Veg Zone Width	9(Left)/6(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	9.4
pH	6.73
Specific Conductance (µS/cm)	3493
Temperature (°C)	9.84
Turbidity (NTUs)	21.7

Church Creek Site CC-02

Sampled: 3/14/2014

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Very Poor
BIBI Score	1.86

Metric	Value	Score
Total Taxa	16	3
EPT Taxa	1	1
Number Ephemeroptera	0	1
% Intolerant to Urban	13.68	3
% Ephemeroptera	0	1
Scraper Taxa	0	1
% Climbers	5.13	3

Benthic Macroinvertebrate Taxa List

Taxa	Count
Argia	4
Caecidotea	15
Calopteryx	1
Cheumatopsyche	2
Conchapelopia	6
Enchytraeidae	1
Gammarus	14
Hemerodromia	1
Orthocladius	25
Paratanytarsus	2
Pisidium	9
Polypedilum	1
Prostoma	1
Rheotanytarsus	1
Stegopterna	1
Tubificidae	33

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Degraded
PHI Score	56.16

Metric	Score
Drainage area (acres)	282.24
Remoteness	23.05
Percent Shading	63.55
Epifaunal Substrate	42.69
Instream Habitat	67.33
Instream Wood Debris	87.41
Bank Stability	52.92

Rapid Bioassessment Protocal

Narrative Rating	Partially Supporting
RBP Score	65

Metric	Score
Epifaunal Substrate / Cover	6
Embeddedness	7
Velocity / Depth Regime	9
Sediment Deposition	13
Channel Flow Status	15
Channel Alteration	13
Frequency of Riffles	14
Bank Stability	5(Left)/6(Right)
Vegetative Protection	2(Left)/3(Right)
Riparian Veg Zone Width	8(Left)/8(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	11.03
pH	7.09
Specific Conductance (µS/cm)	3384
Temperature (°C)	3.08
Turbidity (NTUs)	15.2

Church Creek Site CC-03

Sampled: 3/14/2014

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Very Poor
BIBI Score	1.29

Metric	Value	Score
Total Taxa	13	1
EPT Taxa	0	1
Number Ephemeroptera	0	1
% Intolerant to Urban	5.38	1
% Ephemeroptera	0	1
Scraper Taxa	0	1
% Climbers	6.45	3

Benthic Macroinvertebrate Taxa List

Taxa	Count
Caecidotea	5
Calopteryx	1
Chironomus	1
Crangonyx	1
Cricotopus	4
Dicrotendipes	2
Enchytraeidae	1
Gammarus	52
Ischnura	5
Orthocladius	5
Pisidium	2
Thienemannimyia group	1
Tubificidae	13

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Partially Degraded
PHI Score	70.79

Metric	Score
Drainage area (acres)	282.24
Remoteness	18.60
Percent Shading	40.96
Epifaunal Substrate	94.97
Instream Habitat	95.07
Instream Wood Debris	100.00
Bank Stability	75.11

Rapid Bioassessment Protocal

Narrative Rating	Supporting
RBP Score	81

Metric	Score
Epifaunal Substrate / Cover	13
Embeddedness	11
Velocity / Depth Regime	13
Sediment Deposition	15
Channel Flow Status	17
Channel Alteration	18
Frequency of Riffles	9
Bank Stability	8(Left)/8(Right)
Vegetative Protection	5(Left)/4(Right)
Riparian Veg Zone Width	7(Left)/8(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	8.97
pH	6.87
Specific Conductance (µS/cm)	3356
Temperature (°C)	5.17
Turbidity (NTUs)	14.8

Church Creek Site CC-04

Sampled: 3/14/2014

Biological Condition

Benthic Macroinvertebrate IBI

Narrative Rating	Very Poor
BIBI Score	1.57

Metric	Value	Score
Total Taxa	7	1
EPT Taxa	1	1
Number Ephemeroptera	0	1
% Intolerant to Urban	20.35	3
% Ephemeroptera	0	1
Scraper Taxa	0	1
% Climbers	1.77	3

Benthic Macroinvertebrate Taxa List

Taxa	Count
Caecidotea	23
Cheumatopsyche	1
Gammarus	26
Ischnura	1
Lumbriculidae	1
Polypedilum	1
Tubificidae	60

Physical Habitat

Maryland Biological Stream Survey PHI

Narrative Rating	Degraded
PHI Score	61.01

Metric	Score
Drainage area (acres)	110.53
Remoteness	20.96
Percent Shading	40.96
Epifaunal Substrate	54.61
Instream Habitat	82.47
Instream Wood Debris	100.00
Bank Stability	67.08

Rapid Bioassessment Protocal

Narrative Rating	Partially Supporting
RBP Score	70

Metric	Score
Epifaunal Substrate / Cover	5
Embeddedness	7
Velocity / Depth Regime	6
Sediment Deposition	7
Channel Flow Status	18
Channel Alteration	19
Frequency of Riffles	16
Bank Stability	8(Left)/7(Right)
Vegetative Protection	4(Left)/4(Right)
Riparian Veg Zone Width	9(Left)/8(Right)

Water Chemistry

Dissolved Oxygen (mg/L)	11.01
pH	6.69
Specific Conductance (µS/cm)	3526
Temperature (°C)	7.41
Turbidity (NTUs)	19.5

APPENDIX D

QA/QC INFORMATION

Quality Assurance/Quality Control Summary for NPDES Monitoring Activities

This section describes all Quality Assurance/Quality Control (QA/QC) procedures implemented for this project including field sampling, laboratory sorting and subsampling, data entry, metric calculation, final IBI calculation, geomorphic field sampling, and classification of stream types.

Field Sampling

Initial QA/QC procedures for benthic macroinvertebrate field sampling included formal training for field crew leaders in MBSS Sampling Protocols. All field crew members have attended at least one MBSS Spring Index Period Training. At least one crew member extensively trained and certified in MBSS sampling protocols was present for each field sampling day. Also during field sampling, each data sheet was double checked for completeness and sample bottle labels were double checked for accuracy. Geomorphic assessment field crews have more than one year of experience conducting similar assessment using the Rosgen Stream Classification Methodology.

Geomorphic assessment survey equipment is calibrated annually and regularly inspected to ensure proper functioning. Cross section and profile data were digitally plotted and analyzed in Ohio Department of Natural Resources (ODNR) Reference Reach Spreadsheet Version 4.3L for accuracy.

Water quality QA/QC procedures included calibration of the YSI multiprobe meter daily during the sampling season. Dissolved oxygen probe membranes were inspected regularly and replaced when dirty or damaged.

Laboratory Sorting and Subsampling

Sorting QA/QC was conducted on one sample since only seven samples were collected for this survey. This check consisted of entirely resorting one randomly selected sample to a sorting consistency above ninety percent efficiency. This QC resulted in a sorting efficiency above 95%, so no further action was required. As a taxonomic QC, one sample was re-identified completely by another Versar SFS-certified taxonomist following the same identification methods stated above. The Percent Difference in Enumeration (PDE) and the Percent Taxonomic Disagreement (PTD) were calculated and no further action was required since both the PDE and PTD met MBSS requirements.

Data Entry

All data entered were double checked by someone other than the person who performed the initial data entry. Any errors found during QA/QC were corrected to ensure 100% accuracy of the data.

Metric and IBI Calculations

Ten percent of metric and IBI calculations were checked by hand using a calculator to ensure correct calculation by the Access database. Any discrepancies were addressed at that time.

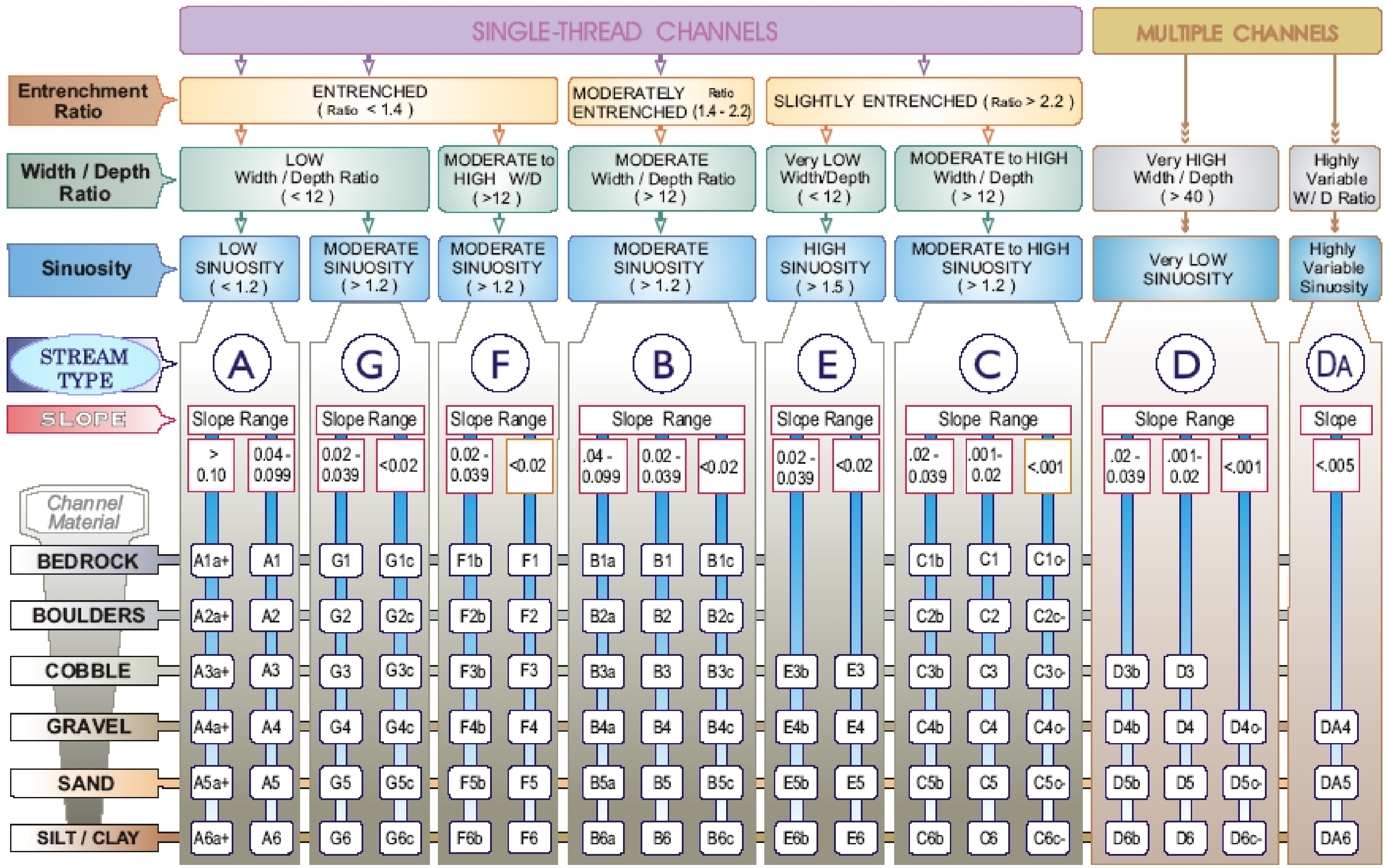
Identification of Stream Types

All stream types were determined by hand based on the methods of the Rosgen Stream Classification (Rosgen, 1996). Due to the natural variability, or continuum, of streams, adjustments in the values of Width Depth Ratio (+/- 2.0) and Entrenchment Ratio (+/-0.2) are allowed, which may result in assigning a different stream type. Therefore, all stream types assigned were checked and any necessary adjustments were made.

APPENDIX E

ROSGEN CLASSIFICATION SCHEME

The Key to the Rosgen Classification of Natural Rivers



KEY to the ROSGEN CLASSIFICATION of NATURAL RIVERS. As a function of the *"continuum of physical variables"* within stream reaches, values of ***Entrenchment*** and ***Sinuosity*** ratios can vary by +/- 0.2 units; while values for ***Width / Depth*** ratios can vary by +/- 2.0 units.

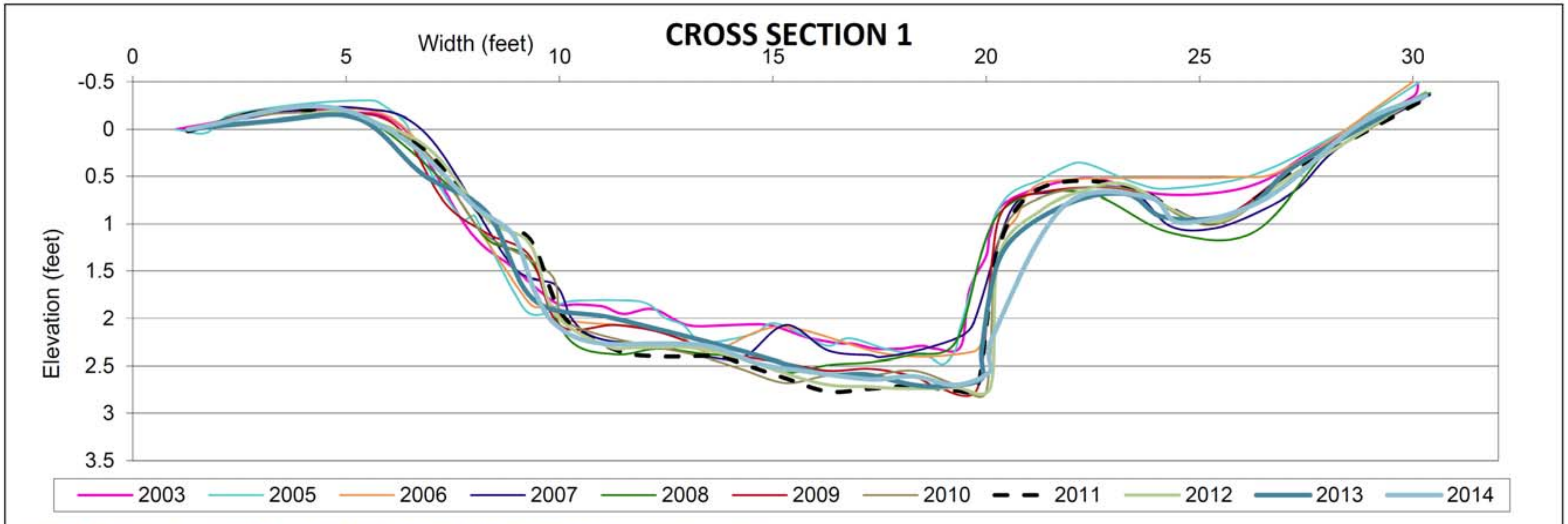
Source: Rosgen, D.L. 1996. *Applied River Morphology*. Wildland Hydrology, Pagosa Springs, CO.

APPENDIX F

GEOMORPHOLOGICAL DATA

Church Creek
2014 Geomorphic Assessment Results Summary

Assessment Parameter	Cross Section				
	XS-1 Pool @ sta 3+70	XS-2 Pool @ sta 6+82	XS-3 Pool @ sta 11+00	XS-4 Pool @ sta 13+53	XS-5 Riffle @ sta 17+36
Classification	F5/4	G4c	G4c	C5	F3
Bankfull Width (ft)	11.4	7.8	7.3	10.8	9.8
Mean Depth (ft)	0.7	0.8	1.0	1.4	0.5
Bankfull X-Sec Area (sq ft)	8.0	6.1	7.4	9.1	5.2
Width:Depth Ratio	16.1	9.9	7.3	12.8	18.5
Flood-Prone Width (ft)	19.0	12.1	9.6	38.0	15.9
Entrenchment Ratio	1.7	1.6	1.3	3.5	1.6
D50(mm)	0.89	11	9	0.74	75
Water Surface Slope (ft/ft)	0.003	0.014	0.003	0.001	0.013
Sinuosity	<1.2	<1.2	<1.2	<1.2	<1.2
Drainage Area (mi2)	0.111	0.113	0.121	0.130	0.441
Adjustments?	Sin ↑, ER ↓	Sin ↑, ER ↓	Sin ↑	Sin ↑	Sin ↑, ER ↓



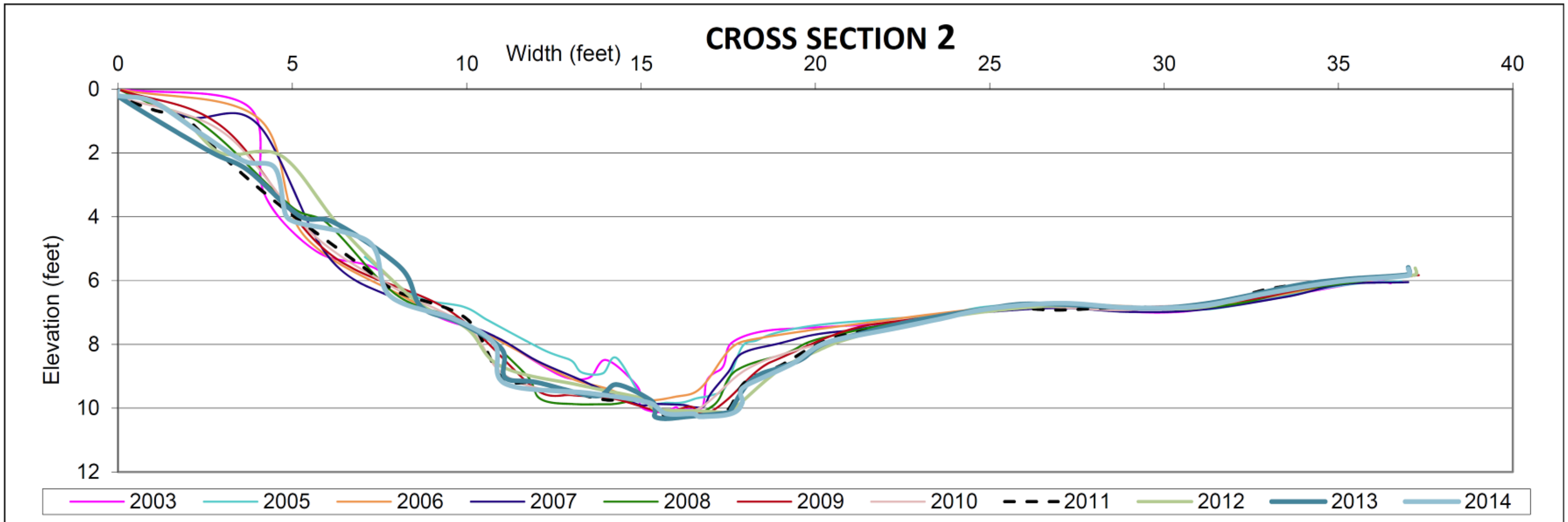
Upstream View

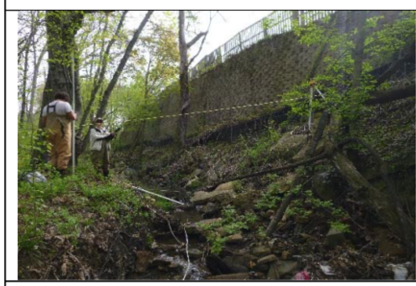
Downstream View

Left Bank View

Right Bank View

2014 Geomorphic Assessment Results	
Bankfull Width (W_{bkf}) (feet)	11.4
Mean Depth (d_{bkf}) (feet)	0.7
Bankfull Cross-sectional Area (A_{bkf}) (feet$_2$)	8.0
Width/Depth Ratio (W_{bkf}/d_{bkf})	16.1
Width of Flood-prone Area (W_{fpa}) (feet)	19.0
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	1.7
Channel Materials D_{50} (millimeters)	0.89
Water Surface Slope (S)	0.003
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑ ER ↓
STREAM TYPE	**F5/4**





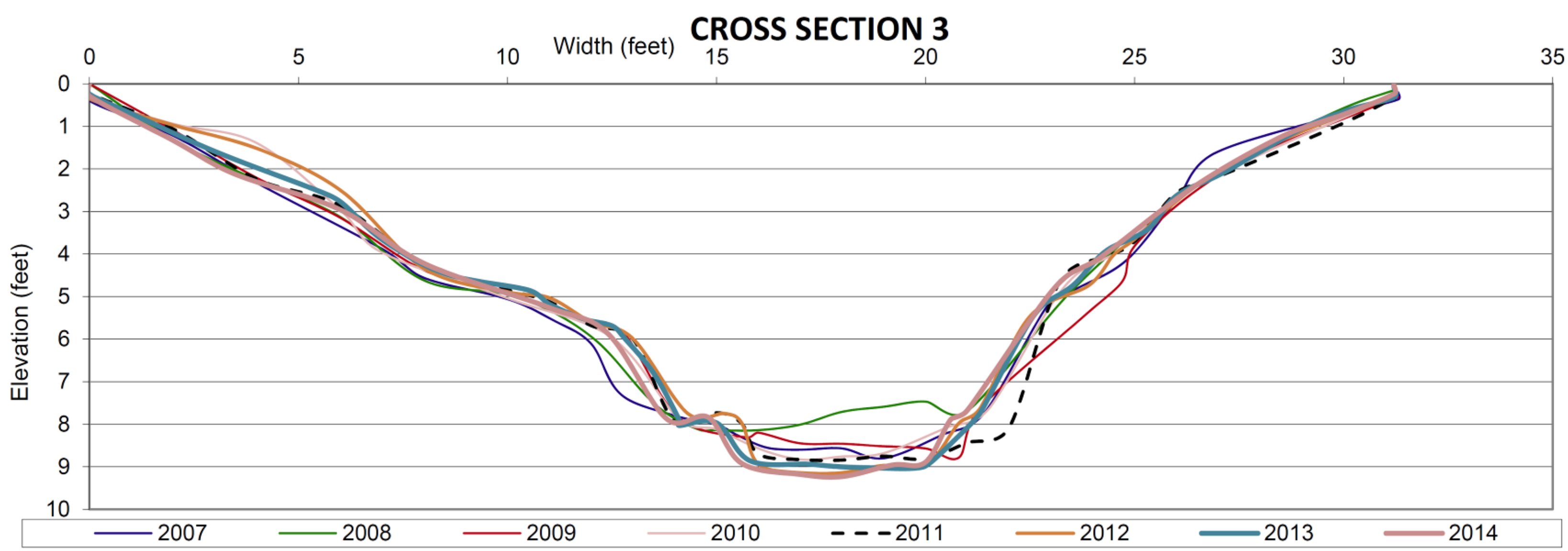
Upstream View

Downstream View

Left Bank View

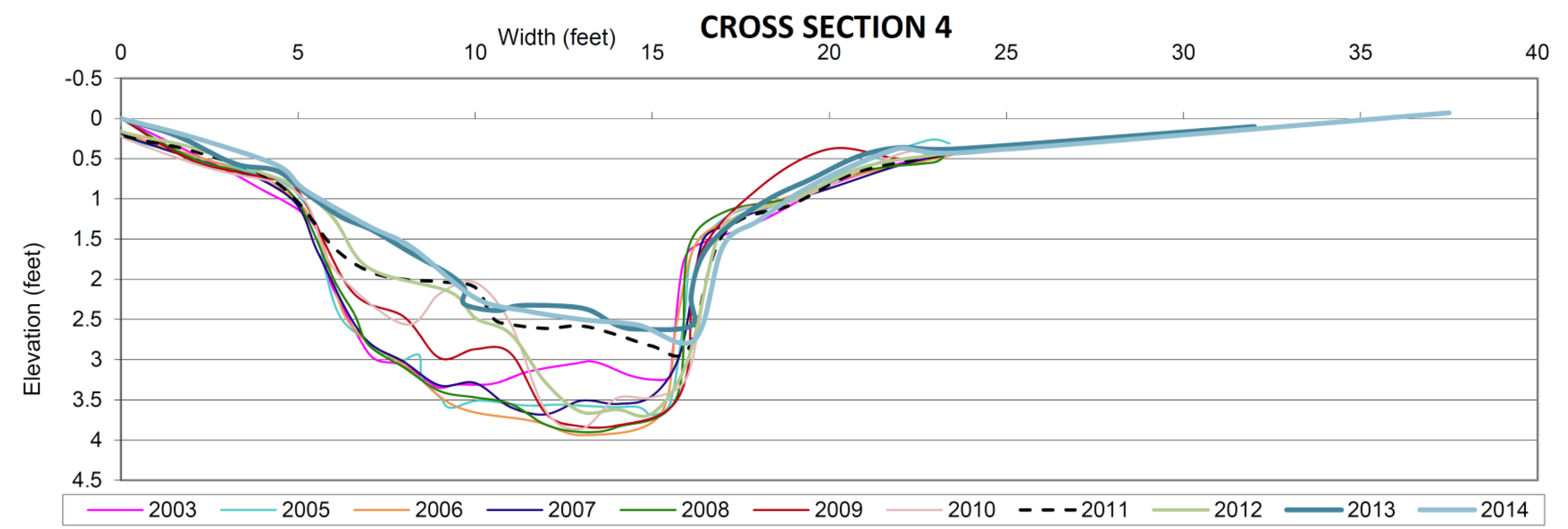
Right Bank View

2014 Geomorphic Assessment Results	
Bankfull Width (W_{bkf}) (feet)	7.8
Mean Depth (d_{bkf}) (feet)	0.8
Bankfull Cross-sectional Area (A_{bkf}) (feet$_2$)	6.1
Width/Depth Ratio (W_{bkf}/d_{bkf})	9.9
Width of Flood-prone Area (W_{fpa}) (feet)	12.1
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	1.6
Channel Materials D_{50} (millimeters)	11
Water Surface Slope (S)	0.014
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑ ER ↓
STREAM TYPE	**G4c**



	
Upstream View	Downstream View
	
Left Bank View	Right Bank View

2014 Geomorphic Assessment Results	
Bankfull Width (W_{bkf}) (feet)	7.3
Mean Depth (d_{bkf}) (feet)	1.0
Bankfull Cross-sectional Area (A_{bkf}) (feet^2)	7.4
Width/Depth Ratio (W_{bkf}/d_{bkf})	7.3
Width of Flood-prone Area (W_{fpa}) (feet)	9.6
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	1.3
Channel Materials D_{50} (millimeters)	9
Water Surface Slope (S)	0.003
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑
STREAM TYPE	**G4c**



Upstream View

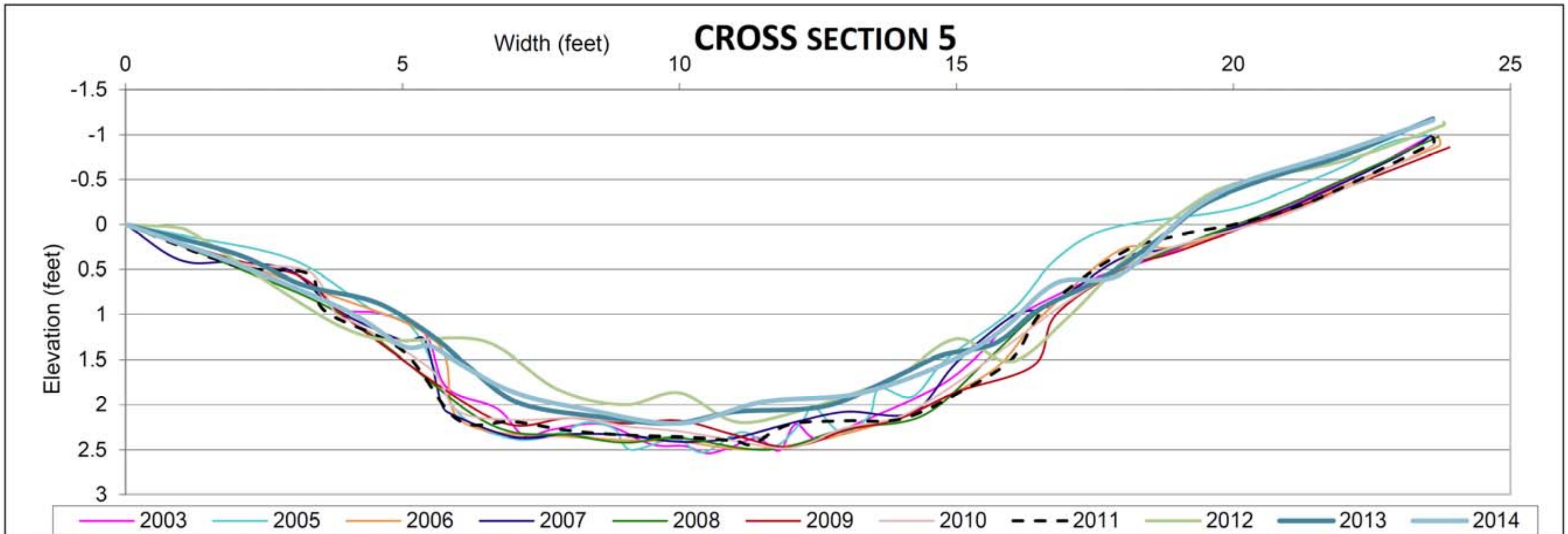
Downstream View

Left Bank View

Right Bank View

2014 Geomorphic Assessment Results

Bankfull Width (W_{bkf}) (feet)	10.8
Mean Depth (d_{bkf}) (feet)	1.4
Bankfull Cross-sectional Area (A_{bkf}) (feet^2)	9.1
Width/Depth Ratio (W_{bkf}/d_{bkf})	12.8
Width of Flood-prone Area (W_{fpa}) (feet)	38.0
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	3.5
Channel Materials D_{50} (millimeters)	0.74
Water Surface Slope (S)	0.001
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑
STREAM TYPE	**C5**



Upstream View

Downstream View

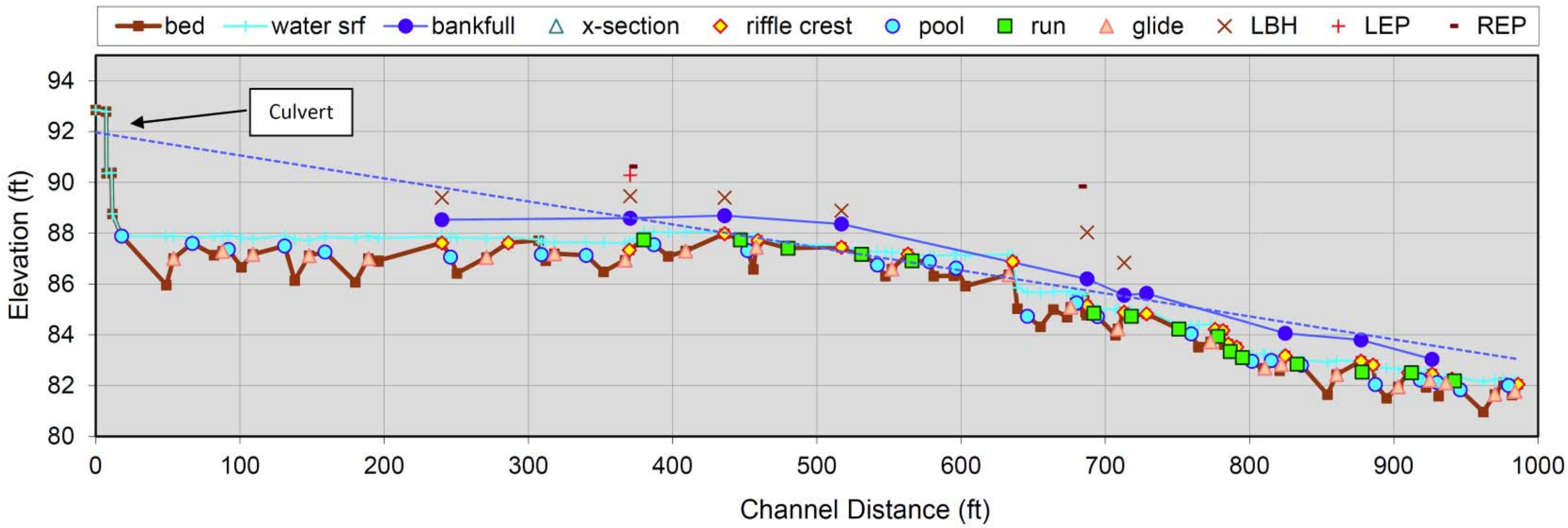
Left Bank View

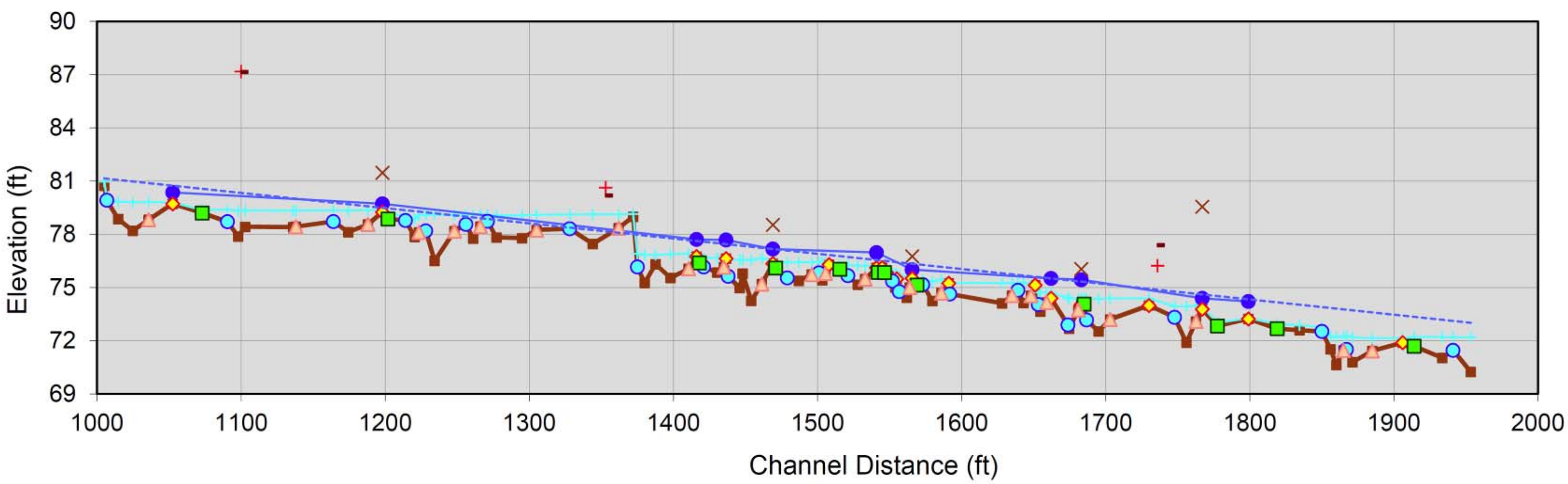
Right Bank View

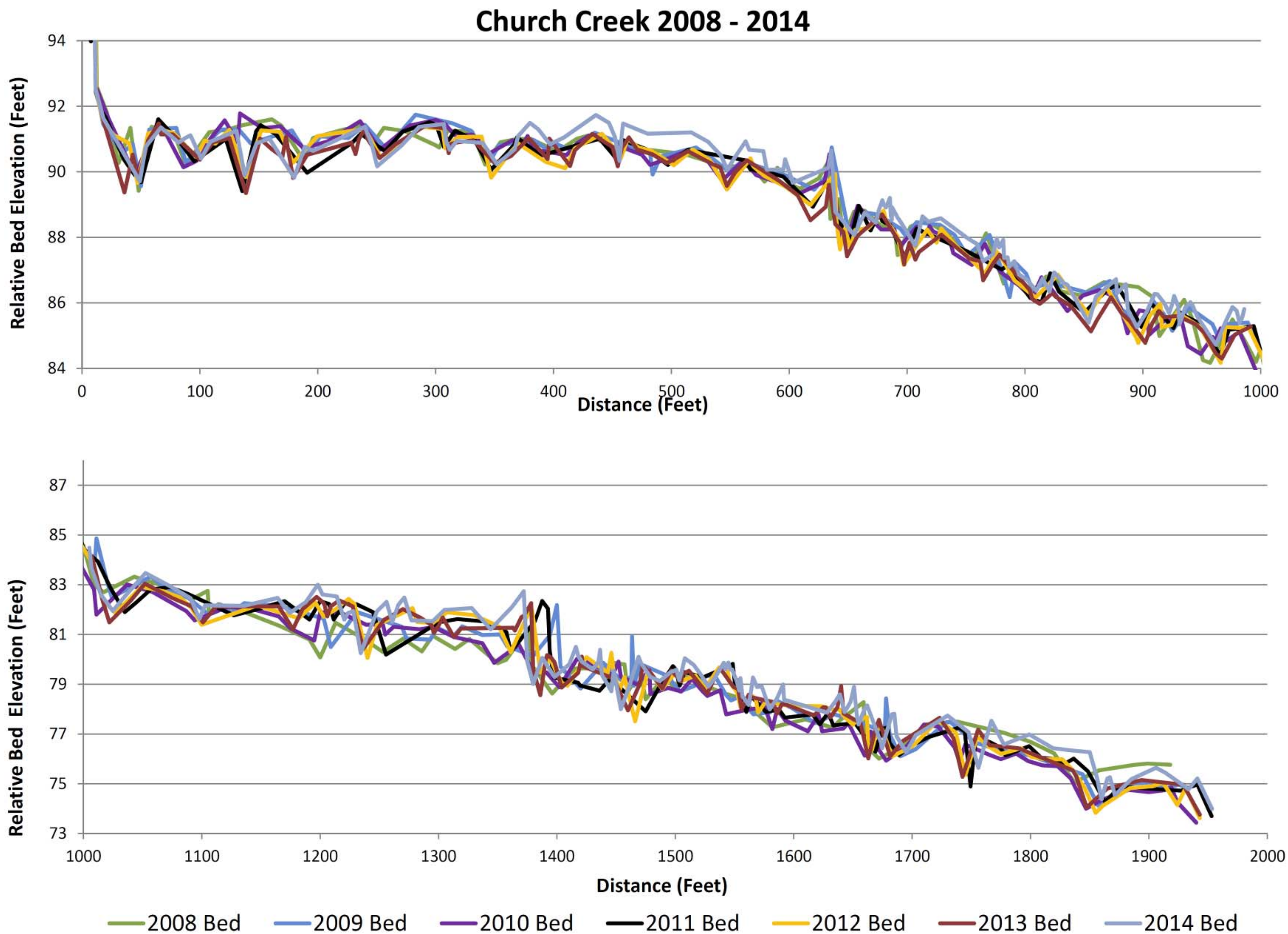
2014 Geomorphic Assessment Results

Bankfull Width (W_{bkf}) (feet)	9.8
Mean Depth (d_{bkf}) (feet)	0.5
Bankfull Cross-sectional Area (A_{bkf}) (feet^2)	5.2
Width/Depth Ratio (W_{bkf}/d_{bkf})	18.5
Width of Flood-prone Area (W_{fpa}) (feet)	15.9
Entrenchment Ratio (ER) = W_{fpa}/W_{bkf}	1.6
Channel Materials D_{50} (millimeters)	75
Water Surface Slope (S)	0.013
Sinuosity (K) = stream length/valley length	<1.2
Adjustments?	Sin ↑ ER ↓
STREAM TYPE	**F3**

Church Creek Longitudinal Profile






Church Creek 2008 - 2014
94
92
90
88
86
84
Relative Bed Elevation (Feet)
0
100
200
300
400
500
600
700
800
900
1000
Distance (Feet)
87
85
83
81
79
77
75
73
Relative Bed Elevation (Feet)
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
2000
Distance (Feet)
2008 Bed
2009 Bed
2010 Bed
2011 Bed
2012 Bed
2013 Bed
2014 Bed

APPENDIX G

CHEMICAL MONITORING RESULTS

Anne Arundel County NPDES
Sampling and EMC Data – 2014 Reporting Year
Parole Plaza Station

Sampler	ID	Jurisdiction	Date	Time	Site	Outfall or Instream	Storm or Baseflow	Depth (Inches)	Duration (Hours)	Intensity (In/Hr)	Temperature - field (oC)	Flow (cf)	pH - field (pH)	dt for BOD (mg/L)	BOD ((0) mg/L)	BOD ((dt) mg/L)	dt for Total Kjeldahl Nitrogen (mg/L)	Total Kjeldahl Nitrogen ((0) mg/L)	Total Kjeldahl Nitrogen ((dt) mg/L)	dt for Nitrate+ Nitrite - N (mg/L)	Nitrate+ Nitrite - N ((0) mg/L)	Nitrate+ Nitrite - N ((dt) mg/L)	dt for Total Phosphorus (mg/L)	Total Phosphorus ((0) mg/L)	Total Phosphorus ((dt) mg/L)	dt for TSS (mg/L)	TSS ((0) mg/L)	TSS ((dt) mg/L)	dt for Copper (mg/L)	Copper ((0) mg/L)	Copper ((dt) mg/L)	dt for Lead (mg/L)	Lead ((0) mg/L)	Lead ((dt) mg/L)	dt for Zinc (mg/L)	Zinc ((0) mg/L)	Zinc ((dt) mg/L)	dt for TPH (mg/L)	TPH ((0) mg/L)	TPH ((dt) mg/L)	dt for E-COLI (MPN)	E-COLI ((0) MPN)	E-COLI ((dt) MPN)	dt for HARDNESS (mg/L)	HARDNESS ((0) mg/L)	HARDNESS ((dt) mg/L)
Versar	1	AP	8/28/2013	1400	101	O	B				21.98	13	7.32	4.00	0.00	4.00	0.50	0.90	0.90	0.05	3.20	3.20	0.01	0.04	0.04	7.0	0.0	7.0	0.002	0.012	0.012	0.002	0.000	0.002	0.02	0.077	0.077	5.0	0.0	5.0	1.0	3873.0	3873.0	1.0	110.0	110.0
										Event Mean Concentration:	**21.98**		**7.32**	**4.00**	**0.00**	**4.00**	**0.50**	**0.90**	**0.90**	**0.05**	**3.20**	**3.20**	**0.01**	**0.04**	**0.04**	**7.0**	**0.0**	**7.0**	**0.002**	**0.012**	**0.012**	**0.002**	**0.000**	**0.002**	**0.02**	**0.077**	**0.077**	**5.0**	**0.0**	**5.0**	**1.0**	**3873.0**	**3873.0**	**1.0**	**110.0**	**110.0**
Versar	1	AP	9/12/2013	1522	101	O	S	0.84	2.0	0.42	23.34	31892	6.90	2.00	5.00	5.00	0.50	1.80	1.80	0.05	0.590	0.590	0.01	0.42	0.420	3.0	86.0	86.0	0.002	0.022	0.022	0.002	0.007	0.007	0.02	0.170	0.170	5.0	0.0	5.0	10.0	4611.0	4611.0	1.0	25.0	25.0
Versar	2	AP	9/12/2013	1537	101	O	S				23.59	93991	6.85	2.00	4.00	4.00	0.50	0.00	0.50	0.05	0.450	0.450	0.01	0.10	0.100	3.0	36.0	36.0	0.002	0.015	0.015	0.002	0.003	0.003	0.02	0.091	0.091	5.0	0.0	5.0	10.0	5794.0	5794.0	1.0	20.0	20.0
Versar	3	AP	9/12/2013	1554	101	O	S				23.61	116291	6.92	2.00	5.00	5.00	0.50	1.20	1.20	0.05	0.910	0.910	0.01	0.18	0.180	3.0	44.0	44.0	0.002	0.029	0.029	0.002	0.002	0.002	0.02	0.120	0.120	5.0	0.0	5.0	10.0	24196.0	24196.0	1.0	40.0	40.0
COMBINED 9/12/2013										**Event Mean Concentration:**	**23.57**		**6.89**	**2.00**	**4.61**	**4.61**	**0.50**	**0.813**	**1.01**	**0.05**	**0.689**	**0.689**	**0.01**	**0.181**	**0.181**	**3.0**	**46.4**	**46.4**	**0.002**	**0.023**	**0.023**	**0.002**	**0.003**	**0.003**	**0.02**	**0.115**	**0.115**	**5.0**	**0.0**	**5.0**	**10.0**	**14474.8**	**14474.8**	**1.0**	**30.3**	**30.3**
Versar	1	AP	9/27/2013	1055	101	O	B				18.20	2	7.10	2.00	4.00	4.00	0.50	0.00	0.50	0.05	6.70	6.70	0.01	0.04	0.04	8.0	0.0	8.0	0.002	0.003	0.003	0.002	0.000	0.002	0.02	0.067	0.067	5.0	0.0	5.0	10.0	20.0	20.0	1.0	150.0	150.0
										Event Mean Concentration:	**18.20**		**7.10**	**2.00**	**4.00**	**4.00**	**0.50**	**0.00**	**0.50**	**0.05**	**6.70**	**6.70**	**0.01**	**0.04**	**0.04**	**8.0**	**0.0**	**8.0**	**0.002**	**0.003**	**0.003**	**0.002**	**0.000**	**0.002**	**0.02**	**0.067**	**0.067**	**5.0**	**0.0**	**5.0**	**10.0**	**20.0**	**20.0**	**1.0**	**150.0**	**150.0**
Versar	1	AP	10/7/2013	1020	101	O	S	0.64	7.0	0.09	22.95	4179	6.80	2.00	25.00	25.00	0.50	4.30	4.30	0.05	6.00	6.00	0.01	0.37	0.37	3.0	100.0	100.0	0.002	0.068	0.068	0.002	0.007	0.007	0.02	0.031	0.031	5.0	0.0	5.0	10.0	24196.0	24196.0	1.0	92.0	92.0
Versar	2	AP	10/7/2013	1310	101	O	S				20.73	37667	7.31	2.00	4.00	4.00	0.50	0.00	0.50	0.05	0.27	0.27	0.01	0.12	0.12	3.0	33.0	33.0	0.002	0.021	0.021	0.002	0.003	0.003	0.02	0.140	0.140	5.0	0.0	5.0	10.0	4569.0	4569.0	1.0	26.0	26.0
Versar	3	AP	10/7/2013	1540	101	O	S				20.48	69715	7.37	2.00	3.00	3.00	0.50	0.00	0.50	0.05	0.48	0.48	0.01	0.10	0.10	3.0	14.0	14.0	0.002	0.015	0.015	0.002	0.000	0.002	0.02	0.086	0.086	5.0	0.0	5.0	10.0	24196.0	24196.0	1.0	31.0	31.0
COMBINED 10/7/2013										**Event Mean Concentration:**	**20.66**		**7.33**	**2.00**	**4.16**	**4.16**	**0.50**	**0.16**	**0.64**	**0.05**	**0.616**	**0.616**	**0.01**	**0.117**	**0.117**	**3.0**	**23.6**	**23.6**	**0.002**	**0.019**	**0.019**	**0.002**	**0.001**	**0.003**	**0.02**	**0.102**	**0.102**	**5.0**	**0.0**	**5.0**	**10.0**	**17569.2**	**17569.2**	**1.0**	**31.6**	**31.6**
Versar	1	AP	12/6/2013	2225	101	O	S	0.61	10.0	0.06	8.54	2733	7.53	2.00	5.00	5.00	0.50	0.90	0.90	0.05	0.73	0.73	0.01	0.12	0.12	3.0	61.0	61.0	0.002	0.025	0.025	0.002	0.004	0.004	0.02	0.190	0.190	5.0	0.0	5.0	10.0	4611.0	4611.0	1.0	38.0	38.0
Versar	2	AP	12/7/2013	0129	101	O	S				6.83	24551	7.55	2.00	0.00	2.00	0.50	0.60	0.60	0.05	0.18	0.18	0.01	0.07	0.07	3.0	26.0	26.0	0.002	0.011	0.011	0.002	0.000	0.002	0.02	0.095	0.095	5.0	0.0	5.0	10.0	4611.0	4611.0	1.0	20.0	20.0
Versar	3	AP	12/7/2013	240	101	O	S				7.73	34601	7.39	2.00	0.00	2.00	0.50	0.00	0.50	0.05	0.45	0.45	0.01	0.08	0.08	17.0	0.0	17.0	0.002	0.011	0.011	0.002	0.000	0.002	0.02	0.073	0.073	5.0	0.0	5.0	10.0	17329.0	17329.0	1.0	30.0	30.0
COMBINED 12/6/2013										**Event Mean Concentration:**	**7.41**		**7.46**	**2.00**	**0.22**	**2.13**	**0.50**	**0.28**	**0.56**	**0.05**	**0.355**	**0.355**	**0.01**	**0.078**	**0.078**	**10.8**	**13.0**	**22.5**	**0.002**	**0.012**	**0.012**	**0.002**	**0.000**	**0.002**	**0.02**	**0.087**	**0.087**	**5.0**	**0.0**	**5.0**	**10.0**	**11721.9**	**11721.9**	**1.0**	**26.39**	**26.39**
Versar	1	AP	12/23/2013	240	101	O	S	0.43	12.0	0.04	14.05	935	7.50	2.00	0.00	2.00	0.50	0.80	0.80	0.05	0.48	0.48	0.01	0.13	0.13	3.0	33.0	33.0	0.002	0.017	0.017	0.002	0.000	0.002	0.02	0.140	0.140	5.0	0.0	5.0	10.0	4884.0	4884.0	1.0	54.0	54.0
Versar	2	AP	12/23/2013	1115	101	O	S				15.23	43119	7.66	2.00	0.00	2.00	0.50	1.20	1.20	0.05	0.22	0.22	0.01	0.27	0.27	3.0	250.0	250.0	0.002	0.047	0.047	0.002	0.010	0.010	0.02	0.290	0.290	5.0	0.0	5.0	10.0	4352.0	4352.0	1.0	100.0	100.0
Versar	3	AP	12/23/2013	1150	101	O	S				14.63	49030	7.48	2.00	7.00	7.00	0.50	0.90	0.90	0.05	0.33	0.33	0.01	0.09	0.09	3.0	18.0	18.0	0.002	0.010	0.010	0.002	0.000	0.002	0.02	0.083	0.083	5.0	0.0	5.0	10.0	3076.0	3076.0	1.0	50.0	50.0
COMBINED 12/23/2013										**Event Mean Concentration:**	**14.90**		**7.6**	**2.00**	**3.69**	**4.63**	**0.50**	**1.04**	**1.04**	**0.05**	**0.281**	**0.281**	**0.01**	**0.174**	**0.174**	**3.0**	**125.6**	**125.6**	**0.002**	**0.027**	**0.027**	**0.002**	**0.005**	**0.006**	**0.02**	**0.179**	**0.179**	**5.0**	**0.0**	**5.0**	**10.0**	**3685.2**	**3685.2**	**1.0**	**73.2**	**73.2**
Versar	1	AP	3/6/2014	1155	101	O	B				6.98	5	7.06	2.00	0.00	2.00	0.50	2.00	2.00	0.05	3.10	3.10	0.01	0.08	0.08	1.0	19.0	19.0	0.002	0.006	0.006	0.002	0.000	0.002	0.02	0.054	0.054	5.0	0.0	5.0	10.0	20.0	20.0	1.0	260.0	260.0
										Event Mean Concentration:	**6.98**		**7.06**	**2.00**	**0.00**	**2.00**	**0.50**	**2.00**	**2.00**	**0.05**	**3.10**	**3.10**	**0.01**	**0.08**	**0.08**	**1.0**	**19.0**	**19.0**	**0.002**	**0.006**	**0.006**	**0.002**	**0.000**	**0.002**	**0.02**	**0.054**	**0.054**	**5.0**	**0.0**	**5.0**	**10.0**	**20.0**	**20.0**	**1.0**	**260.0**	**260.0**
Versar	1	AP	3/18/2014	1420	101	O	B				6.68	16	5.97	2.00	10.00	10.00	0.50	3.80	3.80	0.05	2.10	2.10	0.01	0.18	0.18	1.0	73.0	73.0	0.002	0.025	0.025	0.002	0.003	0.003	0.02	0.180	0.180	5.0	6.0	6.0	10.0	1017.0	1017.0	1.0	180.0	180.0
										Event Mean Concentration:	**6.68**		**5.97**	**2.00**	**10.00**	**10.00**	**0.50**	**3.80**	**3.80**	**0.05**	**2.10**	**2.10**	**0.01**	**0.18**	**0.18**	**1.0**	**73.0**	**73.0**	**0.002**	**0.025**	**0.025**	**0.002**	**0.003**	**0.003**	**0.02**	**0.180**	**0.180**	**5.0**	**6.0**	**6.0**	**10.0**	**1017.0**	**1017.0**	**1.0**	**180.0**	**180.0**
Versar	1	AP	3/28/2014	1430	101	O	B				10.69	15	7.34	2.00	6.00	6.00	0.50	2.20	2.20	0.05	3.90	3.90	0.01	0.13	0.13	1.0	40.0	40.0	0.002	0.022	0.022	0.002	0.000	0.002	0.02	0.150	0.150	5.0	0.0	5.0	10.0	292.0	292.0	1.0	260.0	260.0
										Event Mean Concentration:	**10.69**		**7.34**	**2.00**	**6.00**	**6.00**	**0.50**	**2.20**	**2.20**	**0.05**	**3.90**	**3.90**	**0.01**	**0.13**	**0.13**	**1.0**	**40.0**	**40.0**	**0.002**	**0.022**	**0.022**	**0.002**	**0.000**	**0.002**	**0.02**	**0.150**	**0.150**	**5.0**	**0.0**	**5.0**	**10.0**	**292.0**	**292.0**	**1.0**	**260.0**	**260.0**
Versar	1	AP	4/7/2014	1150	101	O	S	0.29	12.0	0.02	9.18	4659	7.56	2.00	8.00	8.00	0.50	1.60	1.60	0.05	1.10	1.10	0.01	0.12	0.12	1.0	27.0	27.0	0.002	0.031	0.031	0.002	0.000	0.002	0.02	0.170	0.170	5.0	0.0	5.0	10.0	292.0	292.0	1.0	50.0	50.0
Versar	2	AP	4/7/2014	1645	101	O	S				11.71	14342	7.87	2.00	4.00	4.00	0.50	0.80	0.80	0.05	0.36	0.36	0.01	0.14	0.14	1.0	51.0	51.0	0.002	0.024	0.024	0.002	0.003	0.003	0.02	0.140	0.140	5.0	0.0	5.0	10.0	404.0	404.0	1.0	38.0	38.0
Versar	3	AP	4/7/2014	1805	101	O	S				11.48	18128	7.52	2.00	4.00	4.00	0.50	0.80	0.80	0.05	1.20	1.20	0.01	0.09	0.09	1.0	16.0	16.0	0.002	0.016	0.016	0.002	0.000	0.002	0.02	0.095	0.095	5.0	0.0	5.0	10.0	1043.0	1043.0	1.0	52.0	52.0
COMBINED 4/7/2014										**Event Mean Concentration:**	**11.28**		**7.66**	**2.00**	**4.50**	**4.50**	**0.50**	**0.90**	**0.90**	**0.05**	**0.863**	**0.863**	**0.01**	**0.113**	**0.113**	**1.0**	**30.9**	**30.9**	**0.002**	**0.021**	**0.021**	**0.002**	**0.001**	**0.002**	**0.02**	**0.122**	**0.122**	**5.0**	**0.0**	**5.0**	**10.0**	**701.9**	**701.9**	**1.0**	**46.3**	**46.3**
Versar	1	AP	5/27/2014	1920	101	O	S	0.58	3.0	0.19	22.75	1068	7.01	2.00	57.00	57.00	0.50	4.40	4.40	0.05	1.80	1.80	0.01	0.40	0.40	1.0	170.0	170.0	0.002	0.051	0.051	0.002	0.006	0.006	0.02	0.340	0.340	5.0	0.0	5.0	10.0	275.0	275.0	1.0	90.0	90.0
Versar	2	AP	5/27/2014	1930	101	O	S				24.03	5812	7.31	2.00	19.00	19.00	0.50	1.80	1.80	0.05	0.61	0.61	0.01	0.07	0.07	1.0	27.0	27.0	0.002	0.027	0.027	0.002	0.002	0.002	0.02	0.150	0.150	5.0	0.0	5.0	10.0	749.0	749.0	1.0	30.0	30.0
Versar	3	AP	5/27/2014	2135	101	O	S				21.58	17460	7.35	2.00	4.00	4.00	0.50	0.70	0.70	0.05	0.58	0.58	0.01	0.12	0.12	1.0	14.0	14.0	0.002	0.017	0.017	0.002	0.000	0.002	0.02	0.081	0.081	5.0	0.0	5.0	10.0	14136.0	14136.0	1.0	36.0	36.0
COMBINED 5/27/2014										**Event Mean Concentration:**	**22.22**		**7.33**	**2.00**	**9.91**	**9.91**	**0.50**	**1.13**	**1.13**	**0.05**	**0.641**	**0.641**	**0.01**	**0.120**	**0.120**	**1.0**	**23.9**	**23.9**	**0.002**	**0.021**	**0.021**	**0.002**	**0.001**	**0.002**	**0.02**	**0.109**	**0.109**	**5.0**	**0.0**	**5.0**	**10.0**	**10331.2**	**10331.2**	**1.0**	**36.94**	**36.94**
Versar	1	AP	6/19/2014	1730	101	O	S	0.23	3.0	0.08	25.63	2683	7.62	2.00	6.00	6.00	0.50	1.00	1.00	0.05	0.56	0.56	0.01	0.06	0.06	1.0	16.0	16.0	0.002	0.018	0.018	0.002	0.000	0.002	0.02	0.086	0.086	5.0	0.0	5.0	100.0	1580.0	1580.0	1.0	26.0	26.0
Versar	2	AP	6/19/2014	1810	101	O	S				25.40	7675	7.82	2.00	4.00	4.00	0.50	0.00	0.50	0.05	0.28	0.28	0.01	0.07	0.07	1.0	22.0	22.0	0.002	0.017	0.017	0.002	0.004	0.004	0.02	0.130	0.130	5.0	0.0	5.0	100.0	2490.0	2490.0	1.0	30.0	30.0
Versar	3	AP	6/19/2014	1825	101	O	S				24.64	9795	7.65	2.00	6.00	6.00	0.50	0.00	0.50	0.05	0.45	0.45	0.01	0.09	0.09	1.0	18.0	18.0	0.002	0.017	0.017	0.002	0.000	0.002	0.02	0.089	0.089	5.0	0.0	5.0	100.0	68670.0	68670.0	1.0	32.0	32.0
COMBINED 6/19/2014										**Event Mean Concentration:**	**25.06**		**7.7**	**2.00**	**5.24**	**5.24**	**0.50**	**0.13**	**0.57**	**0.05**	**0.400**	**0.400**	**0.01**	**0.078**	**0.078**	**1.0**	**19.3**	**19.3**	**0.002**	**0.017**	**0.017**	**0.002**	**0.001**	**0.003**	**0.02**	**0.104**	**0.104**	**5.0**	**0.0**	**5.0**	**100.0**	**34534.4**	**34534.4**	**1.0**	**30.4**	**30.4**

Anne Arundel County NPDES
Sampling and EMC Data – 2014 Reporting Year
Parole Plaza Station

Sampler	ID	Jurisdiction	Date	Time	Site	Outfall or Instream	Storm or Baseflow	Depth (Inches)	Duration (Hours)	Intensity (In/Hr)	Temperature - field (oC)	Flow (cf)	pH - field (pH)	dt for BOD (mg/L)	BOD ((0) mg/L)	BOD ((dt) mg/L)	dt for Total Kjeldahl Nitrogen (mg/L)	Total Kjeldahl Nitrogen ((0) mg/L)	Total Kjeldahl Nitrogen ((dt) mg/L)	dt for Nitrate+ Nitrite - N (mg/L)	Nitrate+ Nitrite - N ((0) mg/L)	Nitrate+ Nitrite - N ((dt) mg/L)	dt for Total Phosphorus (mg/L)	Total Phosphorus ((0) mg/L)	Total Phosphorus ((dt) mg/L)	dt for TSS (mg/L)	TSS ((0) mg/L)	TSS ((dt) mg/L)	dt for Copper (mg/L)	Copper ((0) mg/L)	Copper ((dt) mg/L)	dt for Lead (mg/L)	Lead ((0) mg/L)	Lead ((dt) mg/L)	dt for Zinc (mg/L)	Zinc ((0) mg/L)	Zinc ((dt) mg/L)	dt for TPH (mg/L)	TPH ((0) mg/L)	TPH ((dt) mg/L)	dt for E-COLI (MPN)	E-COLI ((0) MPN)	E-COLI ((dt) MPN)	dt for HARDNESS (mg/L)	HARDNESS ((0) mg/L)	HARDNESS ((dt) mg/L)
SUMMER QUARTER (JULY, AUGUST, SEPTEMBER)																																														
Summer Quarter Flow-Weighted EMC (9/12/13):											23.57		6.89		4.61	4.61		0.81	1.01		0.69	0.69		0.18	0.18		46.42	46.42		0.02	0.02		0.00	0.00		0.12	0.12		0.00	5.00		14474.08	14474.08		30.27	30.27
Average:															4.61	mg/l		0.91	mg/l		0.69	mg/l		0.18	mg/l		46.42	mg/l		0.023	mg/l		0.003	mg/l		0.115	mg/l		2.50	mg/l		14474.08	MPN/100mL		30.27	mg/l
															0.0002878	lb/cf		0.0000568	lb/cf		0.0000430	lb/cf		0.0000113	lb/cf		0.0028976	lb/cf		0.0000014	lb/cf		0.0000002	lb/cf		0.0000072	lb/cf		0.0001560	lb/cf					0.0018892	lb/cf
Total Volume (Quarter Events):															242,189	cf																														
Pollutant Load (Quarter Events):															69.7	lbs		13.76	lbs		10.42	lbs		2.73	lbs		701.76	lbs		0.34	lbs		0.05	lbs		1.74	lbs		37.79	lbs					457.54	
Total Volume (Quarter):															960,592	cf																														
Pollutant Load (Quarter):															277	lbs		55	lbs		41	lbs		11	lbs		2,783	lbs		1.4	lbs		0.2	lbs		7	lbs		150	lbs					1,815	
FALL QUARTER (OCTOBER, NOVEMBER, DECEMBER)																																														
Fall Quarter Flow-Weighted EMC (10/7/13), (12/6/13), (12/23/13):											15.57		7.44		3.08	3.86		0.49	0.76		0.438	0.438		0.128	0.128		56.79	58.99		0.020	0.020		0.002	0.004		0.126	0.126		0.0	5.0		11362.66	11362.66		44.92	44.92
Average:															3.47	mg/l		0.63	mg/l		0.44	mg/l		0.13	mg/l		57.89	mg/l		0.020	mg/l		0.003	mg/l		0.126	mg/l		2.50	mg/l		11362.66	MPN/100mL		44.92	mg/l
															0.0002165	lb/cf		0.0000392	lb/cf		0.0000274	lb/cf		0.0000080	lb/cf		0.0036132	lb/cf		0.0000013	lb/cf		0.0000002	lb/cf		0.0000078	lb/cf		0.0001560	lb/cf					0.0028035	lb/cf
Total Volume (Quarter Events):															266,529	cf																														
Pollutant Load (Quarter Events):															57.7	lbs		10.44	lbs		7.29	lbs		2.12	lbs		963.02	lbs		0.34	lbs		0.05	lbs		2.09	lbs		41.59	lbs					747.23	
Total Volume (Quarter):															2,103,820	cf																														
Extrapolated Volume (Quarter):															2,317,982																															
Pollutant Load (Quarter):															502	lbs		91	lbs		63	lbs		18	lbs		8,375	lbs		2.9	lbs		0.4	lbs		18	lbs		362	lbs					6,499	
WINTER QUARTER (JANUARY, FEBRUARY, MARCH)																																														
Fall Quarter Flow-Weighted EMC:											8.39		6.69		6.94	7.22		2.88	2.88		2.99	2.99		0.15	0.15		51.75	51.75		0.02	0.02		0.00	0.00		0.15	0.15		2.67	5.44		576.44	576.44		224.44	224.44
Average:															7.08	mg/l		2.88	mg/l		2.99	mg/l		0.15	mg/l		51.75	mg/l		0.021	mg/l		0.002	mg/l		0.150	mg/l		4.06	mg/l		576.44	MPN/100mL		224.44	mg/l
															0.0004421	lb/cf		0.0001800	lb/cf		0.0001866	lb/cf		0.0000091	lb/cf		0.0032300	lb/cf		0.0000013	lb/cf		0.0000001	lb/cf		0.0000094	lb/cf		0.0002531	lb/cf					0.0140089	lb/cf
Total Volume (Quarter Events):															36	cf																														
Pollutant Load (Quarter Events):															0.016	lbs		0.006	lbs		0.007	lbs		0.000	lbs		0.116	lbs		0.000	lbs		0.000	lbs		0.000	lbs		0.009	lbs					0.504	
Total Volume (Quarter):															1,689,634	cf																														
Extrapolated Volume (Quarter):															1,843,238																															
Pollutant Load (Quarter):															815	lbs		332	lbs		344	lbs		17	lbs		5,954	lbs		2.4	lbs		0.2	lbs		17	lbs		467	lbs					25,822	
SPRING QUARTER (APRIL, MAY, JUNE)																																														
Fall Quarter Flow-Weighted EMC (4/7/14), (5/27/14), (6/19/14):											17.94		7.57		6.30	6.30		0.778	0.885		0.682	0.682		0.107	0.107		25.95	25.95		0.02	0.02		0.001	0.002		0.114	0.114		0.00	5.00		11926.88	11926.88		39.61	39.61
Average:															6.30	mg/l		0.83	mg/l		0.68	mg/l		0.11	mg/l		25.95	mg/l		0.020	mg/l		0.002	mg/l		0.114	mg/l		2.50	mg/l		11926.88	MPN/100mL		39.61	mg/l
															0.0003929	lb/cf		0.0000519	lb/cf		0.0000426	lb/cf		0.0000067	lb/cf		0.0016198	lb/cf		0.0000012	lb/cf		0.0000001	lb/cf		0.0000071	lb/cf		0.0001560	lb/cf					0.0024723	lb/cf
Total Volume (Quarter Events):															81,622	cf																														
Pollutant Load (Quarter Events):															32.1	lbs		4.24	lbs		3.48	lbs		0.54	lbs		132.22	lbs		0.10	lbs		0.01	lbs		0.58	lbs		12.74	lbs					201.80	
Total Volume (Quarter):															1,136,586	cf																														
Pollutant Load (Quarter):															447	lbs		59	lbs		48	lbs		8	lbs		1,841	lbs		1.4	lbs		0.1	lbs		8	lbs		177	lbs					2,810	
AVERAGE ANNUAL EMCs:											19.18		7.23		4.33	mg/l		0.772	mg/l		0.575	mg/l		0.146	mg/l		48.77	mg/l		0.021	mg/l		0.003	mg/l		0.120	mg/l		2.50	mg/l		12716.40	mg/l		38.18	mg/l
TOTAL ANNUAL POLLUTANT LOAD (EVENTS):															159.50	lbs		28.44	lbs		21.20	lbs		5.40	lbs		1,797.11	lbs		0.78	lbs		0.102	lbs		4.412	lbs		92.126	lbs					1407.066	lbs
Per Acre:															2.64			0.47			0.35			0.09			29.75			0.01			0.00			0.07			1.53						23.29	
TOTAL 2014 POLLUTANT LOAD:															2,039.81	lbs		536.08	lbs		497.02	lbs		53.58	lbs		18,953.49	lbs		8.12	lbs		0.95	lbs		50.40	lbs		1,155.52	lbs					36,945.03	lbs

Anne Arundel County NPDES
Sampling and EMC Data – 2014 Reporting Year
Church Creek Station

Sampler	ID	Jurisdiction	Date	Time	Site	Outfall or Instream	Storm or Baseflow	Depth (Inches)	Duration (Hours)	Intensity (In/Hr)	Temperature - field (oC)	Flow (cf)	pH - field (pH)	dt for BOD (mg/L)	BOD ((0) mg/L)	BOD ((dt) mg/L)	dt for Total Kjeldahl Nitrogen (mg/L)	Total Kjeldahl Nitrogen ((0) mg/L)	Total Kjeldahl Nitrogen ((dt) mg/L)	dt for Nitrate+ Nitrite - N (mg/L)	Nitrate+ Nitrite - N ((0) mg/L)	Nitrate+ Nitrite - N ((dt) mg/L)	dt for Total Phosphorus (mg/L)	Total Phosphorus ((0) mg/L)	Total Phosphorus ((dt) mg/L)	dt for TSS (mg/L)	TSS ((0) mg/L)	TSS ((dt) mg/L)	dt for Copper (mg/L)	Copper ((0) mg/L)	Copper ((dt) mg/L)	dt for Lead (mg/L)	Lead ((0) mg/L)	Lead ((dt) mg/L)	dt for Zinc (mg/L)	Zinc ((0) mg/L)	Zinc ((dt) mg/L)	dt for TPH (mg/L)	TPH ((0) mg/L)	TPH ((dt) mg/L)	dt for E-COLI (MPN)	E-COLI ((0) MPN)	E-COLI ((dt) MPN)	dt for HARDNESS ((dt) mg/L)	HARDNESS (mg/L)	HARDNESS ((0) mg/L)
Versar	1	AC	8/28/2013	1435	102	I	B				22.2	495	6.9	4.00	0.00	4.00	0.50	0.00	0.50	0.05	1.20	1.200	0.01	0.06	0.060	8.0	0.00	8.0	0.002	0.000	0.002	0.002	0.000	0.002	0.02	0.000	0.020	5.0	0.0	5.0	10.0	420.0	420.0	1.0	120.0	120.0
										Event Mean Concentration:	22.20		6.9	4.00	0.00	4.00	0.50	0.00	0.50	0.05	1.20	1.200	0.01	0.06	0.060	8.0	0.00	8.0	0.002	0.000	0.002	0.00	0.000	0.002	0.02	0.000	0.020	5.0	0.0	5.0	10.0	420.0	420.0	1.0	120.0	120.0
Versar	1	AC	9/12/2013	1515	102	I	S	0.84	2.0	0.42	23.00	1731	6.9	2.00	0.00	2.00	0.50	0.00	0.50	0.05	1.10	1.100	0.01	1.00	1.00	3.0	14.0	14.0	0.002	0.000	0.002	0.002	0.000	0.002	0.02	0.023	0.023	5.0	0.0	5.0	10.0	1450.0	1450.0	1.0	120.0	120.0
Versar	2	AC	9/12/2013	1555	102	I	S				23.80	565667	7.2	4.00	5.00	5.00	0.50	0.00	0.50	0.02	0.09	0.090	0.01	0.20	0.20	1.0	79.0	79.0	0.002	0.017	0.017	0.002	0.007	0.007	0.01	0.110	0.110	5.0	0.0	5.0	10.0	12030.0	12030.0	1.0	38.0	38.0
Versar	3	AC	9/12/2013	1710	102	I	S				24.40	812893	6.9	4.00	0.00	4.00	0.50	0.00	0.50	0.02	0.12	0.120	0.01	0.09	0.09	1.0	18.0	18.0	0.002	0.008	0.008	0.002	0.002	0.002	0.01	0.040	0.040	5.0	0.0	5.0	10.0	12997.0	12997.0	1.0	32.0	32.0
COMBINED 9/12/2013										Event Mean Concentration:	24.15		7.0	4.00	2.05	4.41	0.50	0.00	0.50	0.02	0.109	0.109	0.01	0.136	0.136	1.0	43.0	43.0	0.002	0.012	0.012	0.002	0.004	0.004	0.01	0.069	0.069	5.0	0.0	5.0	10.0	12586.2	12586.2	1.0	34.6	34.6
Versar	1	AC	9/27/2013	1150	102	I	B				16.50	541	6.8	2.00	0.00	2.00	0.50	0.00	0.50	0.05	1.30	1.300	0.01	0.06	0.06	7.0	0.00	7.0	0.002	0.000	0.002	0.002	0.000	0.002	0.02	0.021	0.021	5.0	0.0	5.0	10.0	146.0	146.0	1.0	110.0	110.0
										Event Mean Concentration:	16.50		6.8	2.00	0.00	2.00	0.50	0.00	0.50	0.05	1.30	1.300	0.01	0.060	0.060	7.0	0.00	7.0	0.002	0.000	0.002	0.002	0.000	0.002	0.02	0.021	0.021	5.0	0.0	5.0	10.0	146.0	146.0	1.0	110.0	110.0
Versar	1	AC	10/7/2013	1045	102	I	S	0.64	7.0	0.09	21.1	11109	6.8	2.00	15.00	15.00	0.50	0.80	0.80	0.05	1.60	1.60	0.01	0.20	0.20	3.0	40.0	40.0	0.002	0.009	0.009	0.002	0.000	0.002	0.02	0.053	0.053	5.0	0.0	5.0	10.0	2909.0	2909.00	1.0	110.0	110.0
Versar	2	AC	10/7/2013	1345	102	I	S				21.2	186236	7.0	2.00	6.00	6.00	0.50	1.20	1.20	0.05	0.43	0.43	0.01	0.29	0.29	3.0	90.0	90.0	0.002	0.048	0.048	0.002	0.008	0.008	0.02	0.098	0.098	5.0	0.0	5.0	10.0	14136.0	14136.00	1.0	26.0	26.0
Versar	3	AC	10/7/2013	1625	102	I	S				21.1	532079	7.0	2.00	3.00	3.00	0.50	0.00	0.50	0.05	0.26	0.26	0.01	0.09	0.09	3.0	17.0	17.0	0.002	0.007	0.007	0.002	0.000	0.002	0.02	0.044	0.044	5.0	0.0	5.0	10.0	9208.0	9208.00	1.0	32.0	32.0
COMBINED 10/7/2013										Event Mean Concentration:	21.13		7.0	2.00	3.95	3.95	0.50	0.32	0.68	0.05	0.324	0.324	0.01	0.143	0.143	3.0	36.0	36.0	0.002	0.017	0.017	0.002	0.002	0.004	0.02	0.058	0.058	5.0	0.0	5.0	10.0	10370.28	10370.28	1.0	31.66	31.66
Versar	1	AC	12/6/2013	2250	102	I	S	0.61	10.0	0.06	9.6	378212	7.1	2.00	3.00	3.00	0.50	0.90	0.90	0.05	0.75	0.75	0.01	0.14	0.14	3.0	28.0	28.0	0.002	0.013	0.013	0.002	0.003	0.003	0.02	0.089	0.089	5.0	0.0	5.0	10.0	3076.0	3076.00	1.0	48.0	48.0
Versar	2	AC	12/7/2013	210	102	I	S				7.4	261637	7.1	2.00	0.00	2.00	0.50	0.60	0.60	0.05	0.29	0.29	0.01	0.13	0.13	3.0	35.0	35.0	0.002	0.008	0.008	0.002	0.004	0.004	0.02	0.070	0.070	5.0	0.0	5.0	10.0	3654.0	3654.00	1.0	31.0	31.0
Versar	3	AC	12/7/2013	330	102	I	S				7.4	121401	7.1	2.00	0.00	2.00	0.50	0.00	0.50	0.05	0.23	0.23	0.01	0.06	0.06	17.0	0.0	17.0	0.002	0.004	0.004	0.002	0.000	0.002	0.02	0.056	0.056	5.0	0.0	5.0	10.0	1670.0	1670.00	1.0	31.0	31.0
COMBINED 12/6/2013										Event Mean Concentration:	8.49		7.1	2.00	1.49	2.50	0.50	0.65	0.73	0.05	0.509	0.509	0.01	0.124	0.124	5.2	25.9	28.7	0.002	0.010	0.010	0.002	0.003	0.003	0.02	0.077	0.077	5.0	0.0	5.0	10.0	3050.43	3050.43	1.0	39.4	39.4
Versar	1	AC	12/23/2013	240	102	I	S	0.43	12.0	0.04	13.2	15621	7.0	2.00	0.00	2.00	0.50	0.90	0.90	0.05	0.54	0.54	0.01	0.08	0.08	3.0	9.0	9.0	0.002	0.004	0.004	0.002	0.000	0.002	0.02	0.056	0.056	5.0	0.0	5.0	10.0	2909.0	2909.00	1.0	85.0	85.0
Versar	2	AC	12/23/2013	1145	102	I	S				13.9	459957	7.2	2.00	0.00	2.00	0.50	0.80	0.80	0.05	0.24	0.24	0.01	0.14	0.14	3.0	50.0	50.0	0.002	0.000	0.002	0.002	0.004	0.004	0.02	0.052	0.052	5.0	0.0	5.0	10.0	4352.0	4352.00	1.0	44.0	44.0
Versar	3	AC	12/23/2013	1300	102	I	S				13.9	168909	7.2	2.00	2.00	2.00	0.50	0.00	0.50	0.05	0.00	0.05	0.01	0.00	0.01	3.0	0.0	3.0	0.002	0.000	0.002	0.002	0.000	0.002	0.02	0.000	0.020	5.0	0.0	5.0	1.0	1553.0	1553.00	1.0	0.0	1.0
COMBINED 12/23/2013										Event Mean Concentration:	13.88		7.2	2.00	0.52	2.00	0.50	0.59	0.72	0.05	0.184	0.197	0.01	0.102	0.104	3.0	35.9	36.7	0.002	0.000	0.002	0.002	0.003	0.003	0.02	0.038	0.044	5.0	0.0	5.0	7.6	3583.5	3583.5	1.0	33.5	33.7
Versar	1	AC	3/6/2014	1350	102	I	B				3.8	646	6.4	2.00	0.00	2.00	0.50	4.40	4.40	0.05	1.60	1.60	0.01	0.07	0.070	1.0	14.00	14.0	0.002	0.003	0.003	0.002	0.000	0.002	0.02	0.052	0.052	5.0	0.0	5.0	10.0	213.0	213.0	1.0	200.0	200.0
										Event Mean Concentration:	3.80		6.4	2.00	0.00	2.00	0.50	4.40	4.40	0.05	1.60	1.60	0.01	0.07	0.070	1.0	14.00	14.0	0.002	0.003	0.003	0.00	0.000	0.002	0.02	0.052	0.052	5.0	0.0	5.0	10.0	213.0	213.0	1.0	200.0	200.0
Versar	1	AC	3/18/2014	1345	102	I	B				5.6	835	7.1	2.00	4.00	4.00	0.50	5.60	5.60	0.05	1.60	1.60	0.01	0.07	0.070	1.0	21.00	21.0	0.002	0.004	0.004	0.002	0.000	0.002	0.02	0.056	0.056	5.0	0.0	5.0	10.0	644.0	644.0	1.0	220.0	220.0
										Event Mean Concentration:	5.60		7.1	2.00	4.00	4.00	0.50	5.60	5.60	0.05	1.60	1.60	0.01	0.07	0.070	1.0	21.00	21.0	0.002	0.004	0.004	0.002	0.000	0.002	0.02	0.056	0.056	5.0	0.0	5.0	10.0	644.0	644.0	1.0	220.0	220.0
Versar	1	AC	3/28/2014	1350	102	I	B				8.0	701	6.9	4.00	0.00	4.00	0.50	1.10	1.10	0.05	1.90	1.90	0.01	0.12	0.120	1.0	27.00	27.0	0.002	0.008	0.008	0.002	0.000	0.002	0.02	0.091	0.091	5.0	0.0	5.0	10.0	292.0	292.0	1.0	150.0	150.0
										Event Mean Concentration:	8.00		6.9	4.00	0.00	4.00	0.50	1.10	1.10	0.05	1.90	1.90	0.01	0.12	0.120	1.0	27.00	27.0	0.002	0.008	0.008	0.002	0.000	0.002	0.02	0.091	0.091	5.0	0.0	5.0	10.0	292.0	292.0	1.0	150.0	150.0
Versar	1	AC	4/7/2014	1145	102	I	S	0.29	12.0	0.02	9.1	24098	7.1	2.00	0.00	2.00	0.50	0.90	0.90	0.05	1.80	1.80	0.01	0.12	0.12	1.0	20.0	20.0	0.002	0.005	0.005	0.002	0.000	0.002	0.02	0.065	0.065	5.0	0.0	5.0	10.0	145.0	145.00	1.0	120.0	120.0
Versar	2	AC	4/7/2014	1715	102	I	S				11.2	175533	7.4	2.00	6.00	6.00	0.50	1.30	1.30	0.05	1.00	1.00	0.01	0.26	0.26	1.0	45.0	45.0	0.002	0.016	0.016	0.002	0.005	0.005	0.02	0.100	0.100	5.0	0.0	5.0	10.0	4611.0	4611.00	1.0	68.0	68.0
Versar	3	AC	4/7/2014	1925	102	I	S				11.5	125302	7.4	2.00	4.00	4.00	0.50	0.90	0.90	0.05	0.59	0.59	0.01	0.07	0.07	1.0	14.0	14.0	0.002	0.008	0.008	0.002	0.000	0.002	0.02	0.043	0.043	5.0	0.0	5.0	10.0	813.0	813.00	1.0	57.0	57.0
COMBINED 4/7/2014										Event Mean Concentration:	11.16		7.4	2.00	4.78	4.93	0.50	1.12	1.12	0.05	0.901	0.901	0.01	0.176	0.176	1.0	31.2	31.2	0.002	0.012	0.012	0.002	0.002	0.003	0.02	0.075	0.075	5.0	0.0	5.0	10.0	2815.18	2815.18	1.0	67.61	67.61
Versar	1	AC	5/27/2014	1935	102	I	S	0.58	3.0	0.19		1898	7.3	2.00	10.00	10.00	0.50	1.70	1.70	0.05	0.82	0.82	0.01	0.27	0.27	1.0	20.0	20.0	0.002	0.092	0.092	0.002	0.000	0.002	0.02	0.081	0.081	5.0	0.0	5.0	10.0	557.0	557.00	1.0	60.0	60.0
Versar	2	AC	5/27/2014	1955	102	I	S					36217	7.3	2.00	36.00	36.00	0.50	3.50	3.50	0.05	1.10	1.10	0.01	0.46	0.46	1.0	190.0	190.0	0.002	0.028	0.028	0.002	0.017	0.017	0.02	0.170	0.170	5.0	0.0	5.0	10.0	11199.0	11199.00	1.0	67.0	67.0
Versar	3	AC	5/27/2014	2210	102	I	S					117729	7.5	2.00	4.00	4.00	0.50	1.10	1.10	0.05	0.34	0.34	0.01	0.11	0.11	1.0	25.0	25.0	0.002	0.004	0.007	0.002	0.000	0.002	0.02	0.035	0.035	5.0	0.0	5.0	10.0	3255.0	3255.00	1.0	40.0	40.0
COMBINED 5/27/2014										Event Mean Concentration:			7.4	2.00	11.51	11.51	0.50	1.67	1.67	0.05	0.522	0.522	0.01	0.193	0.193	1.0	63.3	63.3	0.002	0.011	0.013	0.002	0.004	0.005	0.02	0.067	0.067	5.0	0.0	5.0	10.0	5068.27	5068.27	1.0	46.5	46.5
Versar	1	AC	6/19/2014	1740	102	I	S	0.23	3.0	0.08	24.2	7654	6.8	2.00	9.00	9.00	0.50	1.30	1.30	0.05	0.81	0.81	0.01	0.14	0.14	1.0	36.0	36.0	0.002	0.016	0.016	0.002	0.002	0.002	0.02	0.077	0.077	5.0	0.0	5.0	100.0	2310.0	2310.00	1.0	74.0	74.0
Versar	2	AC	6/19/2014	1830	102	I	S				25.5	118856	7.0	2.00	11.00	11.00	0.50	1.10	1.10	0.05	0.64	0.64	0.01	0.24	0.24	1.0	110.0	110.0	0.002	0.020	0.020	0.002	0.014	0.014	0.02	0.130	0.130	5.0	0.0	5.0	100.0	24890.0	24890.00	1.0	46.0	46.0
Versar	3	AC	6/19/2014	1855	102	I	S				25.8	67960	7.0	2.00	6.00	6.00	0.50	0.60	0.60	0.05	0.47	0.47	0.01	0.13	0.13	1.0	50.0	50.0	0.002	0.011	0.011	0.002	0.004	0.004	0.02	0.064	0.064	5.0	0.0	5.0	100.0	29090.0	29090.00	1.0	36.0	36.0
COMBINED 6/19/2014										Event Mean Concentration:	25.55		7.0	2.00	9.17	9.17	0.50	0.93	0.93	0.05	0.587	0.587	0.01	0.198	0.198	1.0	86.1	86.1	0.002	0.017	0.017	0.002	0.010	0.010	0.02	0.105	0.105	5.0	0.0	5.0	100.0	25469.0	25469.0	1.0	43.6	43.6

Anne Arundel County NPDES
Sampling and EMC Data – 2014 Reporting Year
Church Creek Station

Sampler	ID	Jurisdiction	Date	Time	Site	Outfall or Instream	Storm or Baseflow	Depth (Inches)	Durartion (Hours)	Intensity (In/Hr)	Temperature - field (oC)	Flow (cf)	pH - field (pH)	dt for BOD (mg/L)	BOD (0) mg/L	BOD (dt) mg/L	dt for Total Kjeldahl Nitrogen (mg/L)	Total Kjeldahl Nitrogen (0) mg/L	Total Kjeldahl Nitrogen (dt) mg/L	dt for Nitrate+ Nitrite - N (mg/L)	Nitrate+ Nitrite - N (0) mg/L	Nitrate+ Nitrite - N (dt) mg/L	dt for Total Phosphorus (mg/L)	Total Phosphorus (0) mg/L	Total Phosphorus (dt) mg/L	dt for TSS (mg/L)	TSS (0) mg/L	TSS (dt) mg/L	dt for Copper (mg/L)	Copper (0) mg/L	Copper (dt) mg/L	dt for Lead (mg/L)	Lead (0) mg/L	Lead (dt) mg/L	dt for Zinc (mg/L)	Zinc (0) mg/L	Zinc (dt) mg/L	dt for TPH (mg/L)	TPH (0) mg/L	TPH (dt) mg/L	dt for E-COLI (MPN)	E-COLI (0) MPN	E-COLI (dt) MPN	dt for HARDNESS (dt) mg/L	HARDNESS mg/L	HARDNESS (0) mg/L
SUMMER QUARTER (JULY, AUGUST, SEPTEMBER)																																														
Summer Quarter Flow-Weighted EMC (9/12/13):											24.15		7.02		2.05	4.41		0.00	0.50		0.11	0.11		0.14	0.14		42.96	42.97		0.01	0.01		0.00	0.00		0.07	0.07		0.00	5.00		12577.00	12577.00		34.63	34.63
Average:															3.23	mg/l		0.25	mg/l		0.11	mg/l		0.14	mg/l		42.96	mg/l		0.012	mg/l		0.004	mg/l		0.069	mg/l		2.50	mg/l		12577.00	MPN/100mL		34.63	mg/l
															0.0002014	lb/cf		0.0000156	lb/cf		0.0000069	lb/cf		0.0000085	lb/cf		0.0026817	lb/cf		0.0000007	lb/cf		0.0000003	lb/cf		0.0000043	lb/cf		0.0001560	lb/cf					0.0021614	lb/cf
Total Volume (Quarter Events):															1,381,325	cf																														
Pollutant Load (Quarter Events):															278.21	lbs		21.55	lbs		9.47	lbs		11.74	lbs		3,704.25	lbs		1.01	lbs		0.35	lbs		5.92	lbs		215.54	lbs					2,985.63	
Total Volume (Quarter):															24,137,498	cf																														
Pollutant Load (Quarter):															4,862	lbs		377	lbs		165	lbs		205	lbs		64,729	lbs		17.6	lbs		6.1	lbs		103	lbs		3,766	lbs					52,171	
FALL QUARTER (OCTOBER, NOVEMBER, DECEMBER)																																														
Fall Quarter Flow-Weighted EMC (10/7/13), (12/6/13), (12/23/13):											14.44		7.09		2.04	2.84		0.52	0.71		0.348	0.352		0.124	0.124		32.38	33.58		0.010	0.010		0.003	0.003		0.059	0.061		0.0	5.0		5711.96	5711.96		34.98	35.06
Average:															2.44	mg/l		0.62	mg/l		0.35	mg/l		0.12	mg/l		32.98	mg/l		0.010	mg/l		0.003	mg/l		0.060	mg/l		2.50	mg/l		5711.96	MPN/100mL		35.02	mg/l
															0.0001523	lb/cf		0.0000385	lb/cf		0.0000218	lb/cf		0.0000077	lb/cf		0.0020586	lb/cf		0.0000006	lb/cf		0.0000002	lb/cf		0.0000037	lb/cf		0.0001560	lb/cf					0.0021857	lb/cf
Total Volume (Quarter Events):															2,135,160	cf																														
Pollutant Load (Quarter Events):															325.27	lbs		82.22	lbs		46.61	lbs		16.53	lbs		4,395.44	lbs		1.31	lbs		0.39	lbs		7.96	lbs		333.17	lbs					4,666.79	
Total Volume (Quarter):															35,614,106	cf																														
Pollutant Load (Quarter):															5,425	lbs		1,371	lbs		777	lbs		276	lbs		73,315	lbs		21.8	lbs		6.5	lbs		133	lbs		5,557	lbs					77,841	
WINTER QUARTER (JANUARY, FEBRUARY, MARCH)																																														
Fall Quarter Flow-Weighted EMC:											5.84		6.83		1.53	3.41		3.80	3.80		1.70	1.70		0.09	0.09		20.86	20.86		0.00	0.00		0.00	0.00		0.07	0.07		0.00	5.00		403.31	403.31		191.59	191.59
Average:															2.47	mg/l		3.80	mg/l		1.70	mg/l		0.09	mg/l		20.86	mg/l		0.005	mg/l		0.001	mg/l		0.066	mg/l		2.50	mg/l		403.31	MPN/100mL		191.59	mg/l
															0.0001541	lb/cf		0.0002371	lb/cf		0.0001059	lb/cf		0.0000054	lb/cf		0.0013017	lb/cf		0.0000003	lb/cf		0.0000001	lb/cf		0.0000041	lb/cf		0.0001560	lb/cf					0.0119583	lb/cf
Total Volume (Quarter Events):															2,182	cf																														
Pollutant Load (Quarter Events):															0.34	lbs		0.52	lbs		0.23	lbs		0.01	lbs		2.84	lbs		0.00	lbs		0.00	lbs		0.01	lbs		0.34	lbs					26.09	
Total Volume (Quarter):															33,023,295	cf																														
Pollutant Load (Quarter):															5,090	lbs		7,830	lbs		3,497	lbs		177	lbs		42,986	lbs		9.8	lbs		2.1	lbs		136	lbs		5,153	lbs					394,902	
SPRING QUARTER (APRIL, MAY, JUNE)																																														
Fall Quarter Flow-Weighted EMC (4/7/14, 5/27/14, 6/19/14):											12.73		7.28		7.60	7.60		1.19	1.19		0.72	0.72		0.19	0.19		54.42	54.42		0.01	0.01		0.01	0.01		0.08	0.08		0.00	5.00		9859.47	9859.47		55.83	55.83
Average:															7.60	mg/l		1.19	mg/l		0.72	mg/l		0.19	mg/l		54.42	mg/l		0.013	mg/l		0.005	mg/l		0.082	mg/l		2.50	mg/l		9859.47	MPN/100mL		55.83	mg/l
															0.0004744	lb/cf		0.0000743	lb/cf		0.0000452	lb/cf		0.0000116	lb/cf		0.0033965	lb/cf		0.0000008	lb/cf		0.0000003	lb/cf		0.0000051	lb/cf		0.0001560	lb/cf					0.0034848	lb/cf
Total Volume (Quarter Events):															675,248	cf																														
Pollutant Load (Quarter Events):															320.33	lbs		50.16	lbs		30.49	lbs		7.86	lbs		2,293.49	lbs		0.56	lbs		0.23	lbs		3.45	lbs		105.37	lbs					2,353.09	
Total Volume (Quarter):															29,019,342	cf																														
Extrapolated Volume (Quarter):															34,976,955																															
Pollutant Load (Quarter):															16,593	lbs		2,598	lbs		1,579	lbs		407	lbs		118,800	lbs		29.0	lbs		11.8	lbs		179	lbs		5,458	lbs					121,887	
AVERAGE ANNUAL EMCs:											17.36		7.10		3.53	mg/l		0.590	mg/l		0.332	mg/l		0.138	mg/l		39.71	mg/l		0.011	mg/l		0.004	mg/l		0.066	mg/l		2.500	mg/l		8638.074	mg/l		38.323	mg/l
TOTAL ANNUAL POLLUTANT LOAD (EVENTS):															924.15	lbs		154.45	lbs		86.79	lbs		36.14	lbs		10,396.02	lbs		2.87	lbs		0.970	lbs		17.338	lbs		654.417	lbs					10031.606	lbs
Per Acre:															3.31			0.55			0.31			0.13			37.25			0.01			0.00			0.06			2.34						35.94	
TOTAL 2014 POLLUTANT LOAD:															31,969.26	lbs		12,176.74	lbs		6,018.58	lbs		1,065.16	lbs		299,829.88	lbs		78.14	lbs		26.52	lbs		551.18	lbs		19,934.36	lbs					646,801.45	lbs

APPENDIX H

BMP ACRONYMS

LIST OF ACRONYMS

BMP –	best management practice
BR –	bioretention
BS –	baysaver (hydrodynamic structure)
DP –	dry pond
DPW –	department of public works
DW –	dry well
EDSD –	extended detention structure, dry
EDSW –	extended detention structure, wet
ESD MB –	environmental site design, micro bioretention
ESD PERMP –	environmental site design, permeable pavers
ESD –	extended structure dry
ESD SGW –	environmental site design, subsurface gravel wetland
IB –	infiltration basin
IT –	infiltration trench
ITPE –	infiltration trench, partial exfiltration
SW –	swale
USG –	underground storage
WP –	wet pond